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List of abbreviations

AWP – Adria-Wien Pipeline

BRUA – Bulgaria – Romania – Hungary – Austria gas project

BSP – Bratislava-Schwechat Pipeline

CEE – Central-Eastern Europe

CEF – Connecting Europe Facility

EC – European Commission

EIB – European Investment Bank

EFSI – European Fund for Strategic Investments

EOSA – Emergency Oil Stocks Agency

ESIF – European Structural and Investment Fund

EU – European Union

GHG – greenhouse gases

HHI – Herfindahl-Hirschman Index

IAEA – International Atomic Energy Agency

IEA – International Energy Agency

kt – kilotons

ktoe – kilotons of oil equivalent

LNG – liquefied natural gas

MOSES – Model of short-term energy security

MESR – Ministry of Economy of the Slovak Republic

mcm – millions of cubic meters

MW – megawatt

NPP – nuclear power plant

OECD – Organisation for Economic Co-operation and Development

PCI – Project of common interest

PJ – petajoule

SOSR – Statistical Office of the Slovak Republic

TAL – Transalpine Pipeline

TSO – transmission system operator

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1 Introduction

1.1 A short history of Slovak energy dependency

From 4th to 11th of February, 1945, at the end of World War II, the heads of Allied states have met in a seaside city of Yalta on the Crimean Peninsula in the USSR, where they have decided to create a new post-war order, by which the European states were divided into two spheres of influence – the US-led Western bloc, and the USSR-led Eastern bloc. Slovakia, author's country of birth, which is the subject country of this thesis, was designated to be included in the Eastern bloc, as part of the reunited Czechoslovakia. Since the USSR was (within the bloc) the country with largest reserves of oil and gas, and since there was a need for a continuous supply of oil and gas in large quantities for the Czechoslovak industry and households, a construction of two key pipelines from USSR to Czechoslovakia (and other Eastern bloc countries) ensued – the Druzhba (Friendship) oil pipeline, and the Brotherhood gas pipeline.

Even after the Velvet Revolution of 1989, and throughout Slovakia's convergence towards the EU and the West, and even after Slovakia's accession to NATO, both pipelines remained to be the main energy arteries, through which the national economy was powered. To add to the Slovak dependency on Russian sources of energy, Slovakia is also reliant on Russian supply of nuclear fuel (*Slovakia still relies on Russian nuclear fuel,* 2016).

On 7th of January 2009, for the first time since the establishment of the gas pipeline connection from Russia to Europe, in an unprecedented move after unsuccessful price negotiations, Russia has completely stopped sending gas to Europe via Ukraine, which heavily affected Slovakia, since it halted the only existing import route. Thanks to a reverse gas flow from Czech Republic, and to local gas reserves, Slovakia could survive the 13-day period, after which the flow of gas from Ukraine was renewed. (*Zhrnutie priebehu a dopadov krízy,* SPP, 2009).

Since then the tensions between Ukraine and Russia escalated. Annexation of Crimea by Russia, a civil war in the south-eastern Ukraine, and a complete gas cut off of Ukraine only exposed the vulnerabilities of having a single import route. Slovakia has taken an active part of alleviating the crisis by allowing to provide a reverse flow of gas to Ukraine (*Slovakia reaches reverse gas flow deal,* 2014).

As demonstrated above, Slovakia's supply of oil, gas and nuclear fuel is completely contingent on Russia's ability and willingness to supply it. Since Slovakia's production of them is either negligible (oil, gas) or completely non-existent (nuclear fuel), Slovakia has no long-term supply alternatives in case of a total breakdown of imports due to geopolitical or other security risks. Russia therefore possesses a tool, through which it can exert political influence over Slovakia, and it's in Slovakia's interest to alleviate it by developing new supply routes.

1.2 Goals and methods of research

The key issue at hand is Slovakia's complete energy dependence on a single source of energy. The goal of this thesis is to evaluate the energy security of Slovakia, suggest improvements based on the outcomes of the evaluation process, calculate costs of these improvements and suggest an implementation plan with 2030 being the final year of the implementation process. By the end of the process, Slovakia would become a country reaching its highest possible level of energy security, with regards to geographical, economic and geological limitations.

Energy security is defined by the International Energy Agency (IEA) as "uninterrupted availability of energy sources at an affordable price". (IEA, *Energy Supply Security,* pg. 13) From a short-term view, energy security is related to mitigating sudden imbalances between supply and demand, primarily by having enough reserves (if possible) and alternatives supply routes and sources. Long-term energy security is more related to sustainable supply of energy, including replacing of high-pollution energy sources with those less damaging to environment.

It is assumed, that the current supply setup is close to being Pareto optimal in terms of costs – by that logic, making changes to it will cause additional costs. It is also assumed that the risk level is very high and that the potential impact on Slovakia's economy is the highest possible, since it receives the entirety of oil and gas from a single supplier via a transit country hostile toward the energy source country. It is assumed that diversification of source countries and routes would lower the potential impact, and possibly the risk level itself.

Before the evaluation itself starts, the first step is to present the current and predicted future state of affairs in Slovakia, from both data and policy perspective. Current data from 2015, as well as future predictions until 2030, the final year for which the implementation process is planned, will be provided by the Statistical Office of Slovak Republic, unless otherwise stated (SOSR, *Energy 2015*). Policy perspective is based on the official document of the Slovak government *Energy Policy of the Slovak Republic*, published in 2014 (MESR, *Energy Policy*). After presenting current data and state policy, means of project financing will be examined in depth.

Following step is the evaluation process, where the Model of short-term energy supply (referred to as MOSES in the thesis), developed by the International Energy Agency (IEA) in 2011, of which Slovakia is a member state, will be used as the evaluation tool, using data from 2015 (IEA, *MOSES*). Based on the evaluation process, a so-called *model scenario* will be determined, which is a set of improvements Slovakia should implement by 2030 in order to reach its maximum potential energy security level. The model scenario follows only recommendations based by MOSES levels of energy security. It does not take into account other goals that are set by the Energy Policy, namely those related to, among others, share of renewables in the energy mix, CO2 emission reduction, energy efficiency or energy market development. These goals are outside of MOSES' strict energy security scope. Finally, an implementation and cost plan will be designed, with 2018-2030 being the implementation years.

1.3 MOSES as a tool for measuring and improving energy security

MOSES is a model, which allows to evaluate the energy supply security of six primary energy sources: crude oil, natural gas, coal, biomass and waste, hydropower, and nuclear power. Two secondary energy sources are also evaluated: oil products and biofuels. For every energy source, the model assigns the subject country a security profile, usually from A to E, with security profile A being the highest level of supply security and security profile E the lowest. For every energy source, four dimensions are defined:

- External risks: risks associated with potential disruptions of energy imports;
- Domestic risks: risks arising in connection with domestic production and transformation of energy;
- External resilience: ability to respond to disruptions of energy imports by substituting with other suppliers and supply routes;
- Domestic resilience: domestic ability to respond to disruptions in energy supply such as fuel stocks. (IEA, *MOSES*, pg. 10)

For every dimension, a set of indicators is analysed that should accurately describe the risk or resilience dimension related to the energy source. After analysing the indicators, a security profile for each source of energy is compiled by a pre-determined flowchart, specific for each energy source. The flowchart will then assign a security profile from A to E.

The model has several limitations that need to be considered before we further delve into analysis. Firstly, it evaluates the security profiles of energy sources separately, without regarding their importance in the energy mix and/or their capability of being substituted in case of shortages. Furthermore, it establishes uniform ideal energy security goals for all member states, regardless of their economic and diplomatic power. IEA lumps together countries such as e.g.: UK and Slovakia, who have different access to natural resources, different size of economy and a different negotiating position towards major energy suppliers. Goals that may be attainable by a large, energy independent economy may not be readily attainable by a country that is existentially dependent on a monopolistic supplier. Also, as the author herself noted (IEA, *MOSES*, pg. 10), not all indicators could be included into the final version of the model due to the lack of comparable data across all IEA member states. Most notably, the issue of pipeline capacity is not taken into account when evaluating potential entry points for crude oil and natural gas.

There are also several inconsistencies in value ranges of indicators, which will be addressed throughout Chapter 3, whenever they appear. The model also lacks any evaluation of renewables beyond hydropower, biomass and biofuels, possibly because at the time of publishing (2011), the other renewables did not play a key role in IEA members' energy mix.

1.4 Literature survey and other concepts of measuring energy security

MOSES is not the only approach to measuring energy security. Other authors have also contributed to the general discourse around this particular topic. Following is a non-exhaustive list of researchers, who in recent years contributed to our improved knowledge of conceptualizing and measuring energy security.

The first mention will go Kruyt, Bert et. al for their effort in defining indicators for long-term security of energy supply. These indicators were classified in so-called of *four A's of energy security* (availability, accessibility, affordability, and acceptability). Usage of multiple indicators should lead to a broader understanding of energy policy performance (Kruyt et. al., 2009).

Cherp, Aleh and Jewell, Jessica belong among the prolific researchers of energy security. Together, they examined three perspectives on energy security (sovereignty, robustness and resilience), which are rooted in different fields of science. Security challenges threaten energy security across these perspectives, therefore only a multidisciplinary approach should be applied to face them (Cherp – Jewell, 2011). Besides that, an often-mentioned approach of *four A's of energy security* (availability, accessibility, affordability, and acceptability) was analysed and criticized, suggesting a move beyond this approach – conceptualization of energy security as low vulnerability of vital energy systems (Cherp – Jewell, 2014). In addition, Jewell is the author of the MOSES model, conceptualized for the needs of the IEA.

A slightly modified version of *four A's* was used by Sovacool, Benjamin and Brown, Marilyn in order to analyse the performance in the field of energy security of four diverse industrialized countries (Sovacool – Brown, 2010).

Chyong Chi Kong and Hobbs, Benjamin developed a natural gas market model for energy security based on the operations and structure of gas sector in the countries of the Former Soviet Union. The model incorporates various particularities of this gas sector (market powers of transit countries, transmission pipelines, etc.), and is subsequently applied on the example of Nord Stream (Chyong – Hobbs, 2011).

Winzer, Christian tried to come up with a clear concept of the term energy security. Several definitions are reviewed, which can be characterized according to the source of risk, scope of impact and severity characteristics of the impact. Different definitions applied to concrete examples provide different results, ultimately settling for energy security defined as the continuity of energy supply relative to demand (Winzer, 2012).

Nakano Masaru and Prambudia, Yudha and proposed an integrated simulation model for energy security evaluation. Energy security is not measured ex-ante, but ex-post, as a feature that is created by interactions between the components of energy security dimensions. Relationships between these components are then identified and integrated into a coherent evaluation – it is the key focus of the model, which moves away from separate evaluation of indicators (Nakano – Prambudia, 2013).

Lastly, Shin Juneseuk et al. proposed an energy security management model using quality function deployment (QFD) and system dynamics (SD). QFD is utilized to identify key energy security policies and indicators for particular countries in need of a consistent, tailor-made energy policy. The policies and indicators are then used to create a system dynamics model, within which the policies are evaluated by their capability of improving the indicators (Shin et. al., 2013).

2 Energy policy of Slovakia

This chapter is based on the latest version of Energy Policy of the Slovak Republic, published in October 2014. Ministry of Economy of the Slovak Republic is responsible for updating it on a five-year cycle. The policy is largely based on EU energy policy, applying its principles of sustainability and security of energy supplies to Slovak material conditions.

2.1 Current and future energy consumption

In order to plan future investments, it is necessary to have a certain idea about future energy consumption. The quantity of energy needed indicates, whether the policymaker has a certain leeway to alter the composition of energy sources used or not. Slovak policymakers base their policy on three possible scenarios of energy demand – high scenario, reference scenario and energy saving scenario.

Tab. 1: Gross inland energy consumption in Slovakia – future scenarios

Gross inland energy consumption (in PJ)	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
High scenario					797	835	860
Reference scenario	778	803	743	683	765	792	800
Energy saving scenario					735	721	714

Source: Statistical Office of the Slovak Republic, Ministry of Economy

High scenario counts with a relatively high growth of economy, with a stagnation point predicted to be beyond the year 2035. Reference scenario predicts a smaller increase of energy demand, coupled with lowering of energy intensity and lower consumption of coal, which would be, among others, compensated by nuclear energy produced by two new reactors in Mochovce, which are expected to be finished by the end of 2017. Energy saving scenario is similar to reference scenario, with strongly amplified effects of decreasing energy intensity, especially in housing and transport.

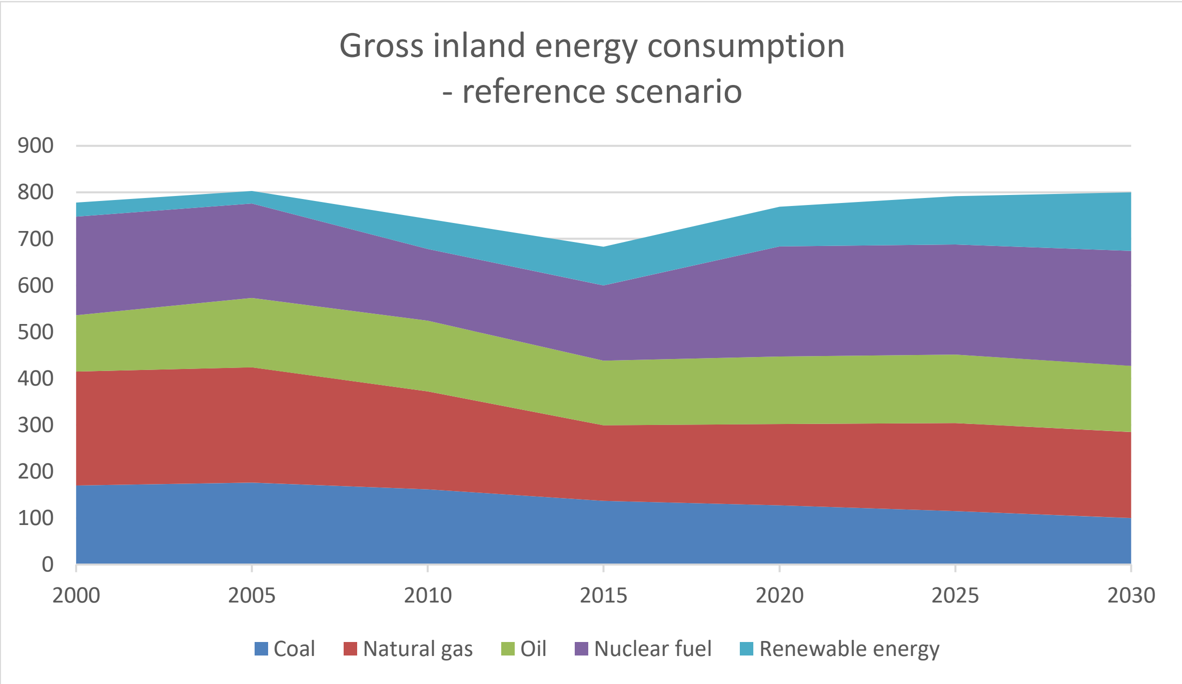
Ministry of Economy considers the reference scenario to be the most likely to take place, and bases its policy around it. The peak energy consumption year is planned to be 2030 – economic growth is supposed to be completely decoupled from rising energy demand by this year. The following table shows the current and future composition of gross inland energy consumption according to the reference scenario.

Tab. 2: Gross inland energy consumption – reference scenario breakdown

Gross inland energy consumption (PJ)	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
Coal	170	176	162	137	127	115	100
Natural gas	245	248	210	162	175	189	185
Oil	121	149	152	139	145	147	142
Nuclear fuel	212	203	154	162	237	237	247
Renewable energy sources	30	27	65	83	85	104	126
Total	**778**	**803**	**743**	**683**	**769**	**792**	**800**

Source: Statistical Office of the Slovak Republic, Ministry of Economy

Fig. 1: Gross inland energy consumption – reference scenario breakdown



Source: Statistical Office of the Slovak Republic, Ministry of Economy

Starting from 2015, the economic recovery is predicted to lead to a gradual growth of energy consumption. To cover the future energy demand, policymakers prefer to expand nuclear infrastructure in Slovakia. Renewables are to be gradually introduced in larger numbers, especially biomass and hydropower, due to relative abundance of both energy sources. Coal will gradually have less importance in Slovakia's energy mix, but will not be phased-out completely anytime soon due to government's social policy.

2.2 *Objectives and measures*

Sustainable energy supply is cited as the very first goal of Slovakia's energy policy (MESR, *Energy Policy,* pg. 21). For a country with no reserves on its own, the fulfilment of this goal is heavily dependent on maintaining good relations with exporting countries (in this case only Russia) and diversification of import routes (which is being addressed in this thesis). Slovak energy policy follows the three pillars of EU energy policy – energy security, market competitiveness and sustainability. Energy security is, as was mentioned in Chapter 1.2, related to mitigation of geopolitical risks and manoeuvring around them in order to ensure continuous and sufficient supply of energy sources. Competitiveness is related to liberal market economy, which is the dominant economic order in EU and based on which rules should energy markets operate. Sustainability is an idea centred around the environmental impact of non-renewable energy sources utilization – the harm it causes should be limited to such a degree, that it does not deteriorate the living conditions of mankind beyond a recoverable point.

Alongside these principles, energy efficiency was added by Slovak policymakers. This is related not only to transportation, but mostly to efficiency measures in industry and housing. Most strategic industrial infrastructure and housing for urban industrial labourers was built during the socialist regime, and in the last years (mostly thanks to EU funding) there has been a lot of investment undergone in order to lessen heat and electricity losses accrued during operating these facilities.

The following priorities named by the Slovak energy policy are related to energy security:

- optimising the energy mix – this is largely related to the slow decline of coal and the rising share of renewables in the mix;
- increase the security of energy supply – the entire Chapter 3 will explore possibilities of increasing supply security;
- develop energy infrastructure – supported by the Connecting Europe Facility financing scheme;
- diversify energy sources and transport routes – possible alternatives will be discussed in Chapter 3;

- maximise the utilization of transmission networks and transit systems passing through Slovakia – this in effect means, that Slovakia will lobby for projects involving Slovakia as a transit country, and that will lobby against rival projects; for instance, the recently planned expansion of gas pipeline Nord Stream, directly connecting Russia and Germany through the Baltic Sea, has met strong protests from all transit countries between Russia and Germany, including Slovakia.
- utilise nuclear energy as a zero-carbon source of energy – this is a clear signal, that Slovakia will remain among the countries with highest share of electricity produced from nuclear fuel, despite pressures from Austria and Germany (IAEA, *Nuclear Share)*;
- increase the safety and reliability of nuclear power plants (MESR, *Energy Policy,* pg. 22).

Measures used for implementing of these priorities are mainly about legislative implementation, utilization of financial schemes from EU and state funds and maintaining of independence of the Regulatory Office.

Renewables also play a role in Slovak energy policy. According to the Slovak policymakers, biomass has the largest potential among renewables – it could supply 120 PJ of energy (MESR, *Energy Policy,* pg. 60). It is argued that they would boost local economies and that they could be a vital step towards a low-carbon economy. However, over-utilization of biomass may backfire, if there will be issues with water scarcity due to global warming.

Slovakia is obliged to increase the use of renewables compared to gross final energy consumption to 14% (or 80 PJ) by 2020, and to 20% (or 120 PJ) by 2030. Note that obligations themselves are slightly different from government predictions in Chapter 2.1.

2.3 Increasing energy security

The Slovak energy policy paper lists many measures regarding energy security. These ones are of particular interest to the thesis:

<u>Support infrastructure projects facilitating the diversification of energy sources:</u>

The latest list of Projects of Common Interest (PCIs), published by the European Commission in January 2016 (EU, *2016/89*) includes the following projects, in which Slovakia is involved:

- Increase of electricity transmission capacity between Hungary and Slovakia – this would be done at three different points along the Slovak-Hungarian border (EU, *2016/89,* pg. 10);
- Construction of a Polish-Slovak gas interconnection – the construction aid has been granted by the Commission, the project should be finished by 2019 (EC, *PCI 6.2.1*);
- Construction of a gas pipeline system from Slovakia to Bulgaria – currently undergoing a feasibility study (EC, *PCI 6.25.1*), in addition there are several other PCIs that may be considered as rival projects, such as Greece-Austria gas pipeline or BRUA gas project (EU, *2016/89,* pg. 16); the approval of the Slovak-Bulgarian pipeline (also known as Eastring) would be considered to be a major success of the Slovak economy, since it's a project spearheaded by the Slovak gas TSO Eustream, and since there are other rival projects as it was mentioned above;
- Construction of an oil pipeline between Bratislava and Schwechat, Austria (EU, *2016/89,* pg. 18);
- Expansion of the Adria pipeline from Omišalj, Croatia through Hungary to the Druzhba pipeline in Slovakia (ibid.).

However, possibilities of improving energy security through international infrastructure projects do not end at the PCI list. Chapter 3 deals with possible infrastructure projects for each energy source, if the state of its supply security demands it.

Other energy security measures include:

- Completion of nuclear power plant (NPP) Mochovce 3 and 4 and building of a new NPP in Jaslovské Bohunice – this only confirms that the energy policy of the next decades will be heavily nuclear-centric;
- Maintaining the use of coal until 2020 with an outlook towards 2035, and preservation of at least two production units (2 x 110 MW) at the Nováky Power Plant – the official reason for this decision is to preserve stability of electricity supply for neighbouring industrial region; it could be argued, however, that both Slovak nuclear power plants, which are relatively close the Nováky Power Plant, could easily replace its task, with nearby hydropower plants being the reserve for peak hours (MESR, *Energy Policy*, pg. 25). Unofficially, both coal production and the coal power

plant are kept in operation due to social reasons – their immediate closure would cause a huge unemployment spike in the region.

2.4 Electricity production

Tab. 3: Net maximum electric capacity in Slovakia (2015)

Net maximum electric capacity (2015)	**MW**	**%**
Hydropower	2522	32,42%
Nuclear	1940	24,94%
High-carbon (oil, coal, multifuel)	1627	20,92%
Low-carbon (natural gas)	959	12,33%
Solar	533	6,85%
Other renewables (biofuels, waste, wind)	168	2,16%
Other fuel sources	30	0,39%
Total	**7779**	**100,00%**

Source: Energy 2015, Statistical Office of the Slovak Republic

Tab. 4: Gross electricity production in Slovakia (2015)

Gross electricity production (2015)	**GWh**	**%**
Nuclear power	15146	56,30%
Combustible fuels	7008	26,05%
Hydropower	4137	15,38%
Solar	506	1,88%
Other fuel sources	100	0,37%
Wind	6	0,02%
Total	**26903**	**100,00%**

Source: Energy 2015, Statistical Office of the Slovak Republic

Based on government data, we can see that Slovakia is provided with ample hydropower capacity (with 35% of it is used as pumped storage) (MESR, *Energy Policy,* pg. 142). Nuclear power remains and will continue to be the baseload source of electricity in Slovakia for public purposes. Hydropower and several fossil-fuel and biofuel plants are utilised during peaks, whereas other combustible fuel plants are used for industrial purposes. Share of other renewables on production, especially of solar, is lagging quite behind their capacity share. Slovakia has less potential for its utilization due to its mountainous profile and mild climate. In 2015, Slovakia had a net import of 8,87% of its gross electricity consumption (MESR, *Energy Policy,* pg. 143).

With the finishing of the two new Mochovce reactors, we may expect Slovakia to become a net exporter of electricity. Their installed capacity will be 2x471 MW. A new plant at Jaslovské Bohunice, planned to be constructed after 2025, is projected to have at least 1200 MW capacity in total. The remaining reactors at Jaslovské Bohunice (called NPP V2 in the paper), that are currently in operation, are considered for a lifespan extension until 2045 (MESR, *Energy Policy,* pg. 68). Two new hydropower plants are planned to be built beside the main nuclear projects. One of them would be situated near the town of Sereď on the river Váh, planned to generate around 180 GWh of electricity per year, although its construction is dependent on favourable energy prices. The second one would be a pumped storage dam on the river Ipeľ, used as a backup for nuclear power plants, with a design capacity of 600 MW. Its construction depends also on electricity prices and interests of entities in ownership (MESR, *Energy Policy,* pg. 71).

2.5 Financing of Slovak energy security projects

By default, an energy project is carried out by a company or a consortium of companies, which are usually in hands of respective national governments, but also with considerable shares of private investors. For projects of EU-wide importance, the European Commission established a funding instrument called Connecting Europe Facility (CEF), which awards financial assistance to infrastructure projects in transport, telecommunication and energy. The current rounds of grants started in 2014 and lasts until 2020, within which an amount of 5,35 billion € is available for energy infrastructure projects (EC, *CEF Energy*).

In order to benefit from EU funding, a project has to be registered by the CEF as a Project of Common Interest (PCI). A project must fulfil several criteria in order to be included among the PCIs:

- have a significant impact on at least two EU countries;
- enhance market integration and contribute to the integration of EU countries' networks;
- increase competition on energy markets by offering alternatives to consumers;
- enhance security of supply;
- contribute to the EU's energy and climate goals (Ibid.).

A list of these projects is updated every two years, in order to filter out completed projects or projects deemed unfeasible. Besides having the possibility to compete for financial grants, PCIs benefit from accelerated permit granting and improved regulatory treatment.

CEF gives out grants to PCIs after completing a round for proposals, which take place every year. Grants may be awarded for feasibility studies and for construction costs – however, only those projects that "face difficulties in their commercial viability" despite the benefits that they bring. A cost-benefit analysis is applied to determine its level Outside of CEF grants, there are other funds available for PCIs, such as European Fund for Strategic Investments (EFSI) and European Structural and Investment Fund (ESIF). Financial instruments of the European Investment Bank (EIB) may also help with financing of projects. This is especially necessary for oil infrastructure projects, who are awarded no grants from CEF itself (EC, *PCIs in energy,* 2015).

3 Energy security in Slovakia – a MOSES analysis

3.1 Application of the model

The entire Chapter 3 is dedicated to the analysis of Slovak energy security by using the MOSES model. Before the supply of individual energy sources will be analysed, there must be a set of uniform rules of model application. This is due to model having its own biases and inconsistencies, and these rules are meant to rectify them.

The most important rule for planning new projects is the so-called *selfish choice rule* – if there are multiple possible projects, that would fulfil the same goal, the one that directly involves Slovakia is the one that will be prioritized. E.g.: a North-South gas corridor project, connecting Central European gas infrastructure with East Balkan countries, could follow multiple routs, including or excluding Slovakia. The one that involves Slovakia as a final destination or a transit country is the one chosen. From all possible permutations of countries involved, the ones that are EU members are preferred. The project should involve the least number of countries needed for fulfilling its goal, unless it's an already existing project. In that case, the original number of countries involved stays the same.

The model has a strong bias towards countries having access to sea ports when evaluating the security of crude oil, oil products, gas, coal and biofuels supply. This disallows inland countries to reach higher ranks of energy security within the model. An inland country will be understood to have access to a sea port if the port is within a territory of a member country of the EU, if there is a connection to it via pipeline or railway (depending on the energy source), and if the connection is intended to be used for supplying the inland country; this means that the connection has capacity, or can free up capacity in order for Slovakia to be able to import the energy source. This will be referred to as *port rule*.

There are several incorrect intervals between value ranges of indicators, in addition to other inconsistencies in wording or evaluation flowcharts. These are addressed in the respective subchapters, whenever they occur.

The entire analysis is based on latest available annual data, published by the Statistical Office of the Slovak Republic in their report Energy 2015. These data, and calculations based on these data are used throughout this chapter as the primary source of information, unless otherwise stated.

3.2 Crude oil

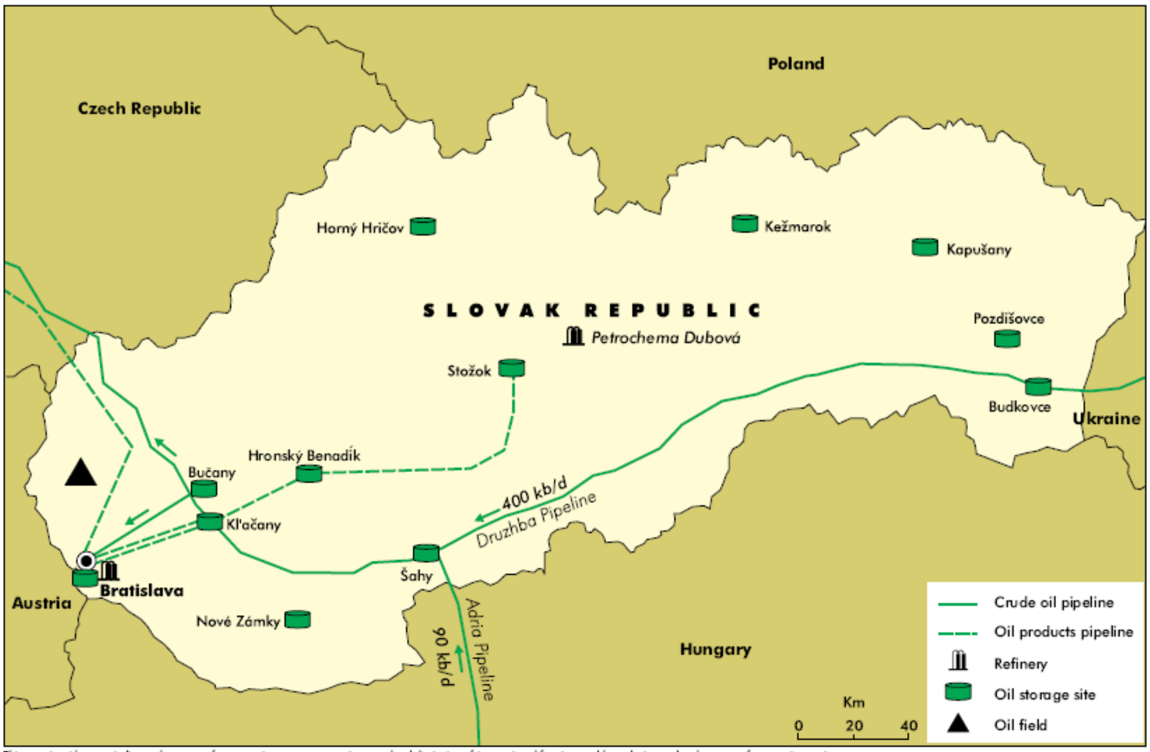
Tab. 5: Crude oil balance (2015)

Crude oil (2015)	ktoe	TJ
Production	10	419
Import	5 902	247 106
Export	10	419
Stock change	28	1 173
Refinery intake	**5 930**	**248 277**

Source: Energy 2015, Statistical Office of the Slovak Republic

Fig. 2: Oil infrastructure of Slovakia

Map 4.23.1 Oil infrastructure of the Slovak Republic



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Source: Energy Supply Security 2014, International Energy Agency

In year 2015, virtually all consumed crude oil was imported. The domestically produced crude oil in Gbely oil field, near the capital city, was exported in its entirety to Austria. The imported crude oil arrives from Russia via the Druzhba (Friendship) pipeline, and was in that year the only pipeline that is used to import oil to Slovakia. The pipeline then leads to Czech Republic via continuation of Druzhba. The Adria pipeline allows import of oil from the Croatian port of Omišalj, but may be used in both ways. Since 2016, oil started to flow through the newly reconstructed Adria pipeline, with its capacity to be used for Slovakia grown to 6 million tons per year.

MOSES identifies the following indicators and range values for crude oil:

Fig. 3: Crude oil - indicators

Table 3 Crude oil: indicators

	Risks	Resilience
External	**External risks:** • import dependence • political stability of suppliers	**External resilience:** • number of ports • number of pipelines • diversity of suppliers
Domestic	**Domestic risks:** • share of offshore production • volatility of domestic production	**Domestic resilience:** • average storage level

Source: The IEA Model of Short-term Energy Security (MOSES), 2011

Fig. 4: Crude oil – ranges for indicators

Table 4 Crude oil: ranges for indicators

Dimension	Indicator		Low		Medium		High
External risk	Import dependency		≤15%		40%-65%		≥80%
	Political stability of suppliers		<2.5		≥2.9		
Domestic risk	Volatility of production		<20%		>20%		
	Share of offshore production		<15%		>90%		
External resilience	Diversity of suppliers		>0.8		0.30-0.8		<0.30
	Import infrastructure (entry points)	Ports	0	1	2	3-4	≥5
		Pipelines	1	2	3-4	5-8	≥9
Domestic resilience	Storage levels		≤15		20-50		≥55

Source: The IEA Model of Short-term Energy Security (MOSES), 2011

<u>External risk: Import dependence</u>

Import dependence designates the share of foreign energy source on the whole national consumption in a year. As it was mentioned above, almost all crude oil consumed in Slovakia is imported. This makes Slovakia a country completely dependent on crude oil import.

Value: High (≥ 99%)

External risk: Political stability of suppliers

Political stability is a value published by OECD, through which they classify the risk of importing goods from the evaluated country. The values range from 1 to 7, where 1 is given to most secure exporting countries and 7 to least secure; many high-income countries are exempted from evaluation, and it is assumed that the value of their political stability regarding exports is 1. This value is then calculated as a weighted average of all importers by their proportion on total import. In year 2015, the only crude oil importer to Slovakia was Russia (SOSR, *Energy 2015,* p. 116). The calculation of this value is in this case straightforward, with Russia being classified 4 on the 1-7 scale (OECD, *Country Risk Classifications*). The risk associated with the political stability of crude oil suppliers is high in Slovakia's case.

Value: High (4.00, 1.00-7.00 scale)

Domestic risk: Share of offshore production

Slovakia, as a landlocked country, has no means for offshore production.

Value: N/A

Domestic risk: Volatility of domestic production

Slovakia's domestic production is lower than 0,2% of its consumption, and none of it consumed at home, since the same amount is being exported to Austria. Calculation of production volatility would therefore have no impact on the total evaluation of Slovakia's energy supply security.

Value: N/A

External resilience: Diversity of suppliers

Diversity of suppliers is calculated by a Herfindahl-Hirschman Index (HHI). Since Russia was in 2015 a monopolistic supplier, the value is 1, i.e. total concentration of supply by a monopolist.

Value: Low (1.00)

External resilience: Number of entry points - ports and pipelines

As a landlocked country, Slovakia has no own access to a port, however by applying the port rule, Slovakia has access to the port in Omišalj, Croatia via the Adria pipeline. This would allow Slovakia to purchase crude oil on the spot market and have access to it by sea through Croatia and Hungary. Slovakia has theoretically a pipeline access to the port in Trieste, Italy via four different transit countries; Italy, Austria and Germany through TAL, from Germany to Czech

Republic through KLA pipeline. Currently there is no reverse flow technology on the Druzhba pipeline, which would require additional investment at the pumping stations. There is however no intention of using it to supply Slovakia with Omišalj being close to Trieste and having the capacity and intention to be used in case there are supply shortages from Russia.

Entry points for pipelines are counted for every single place, where an oil pipeline crosses the national border. As it is visible on the map above, the Druzhba pipeline stretches from the Slovak-Ukrainian border to Czech Republic, and the Adria pipeline is connected to it from Hungary.

Value: Middle (3 pipeline entry points), Low (1 port) – the worse of the two scores is valid for the final evaluation. Slovakia therefore receives a **Low** score for having a direct access to **1 port**.

Domestic resilience: Average storage level

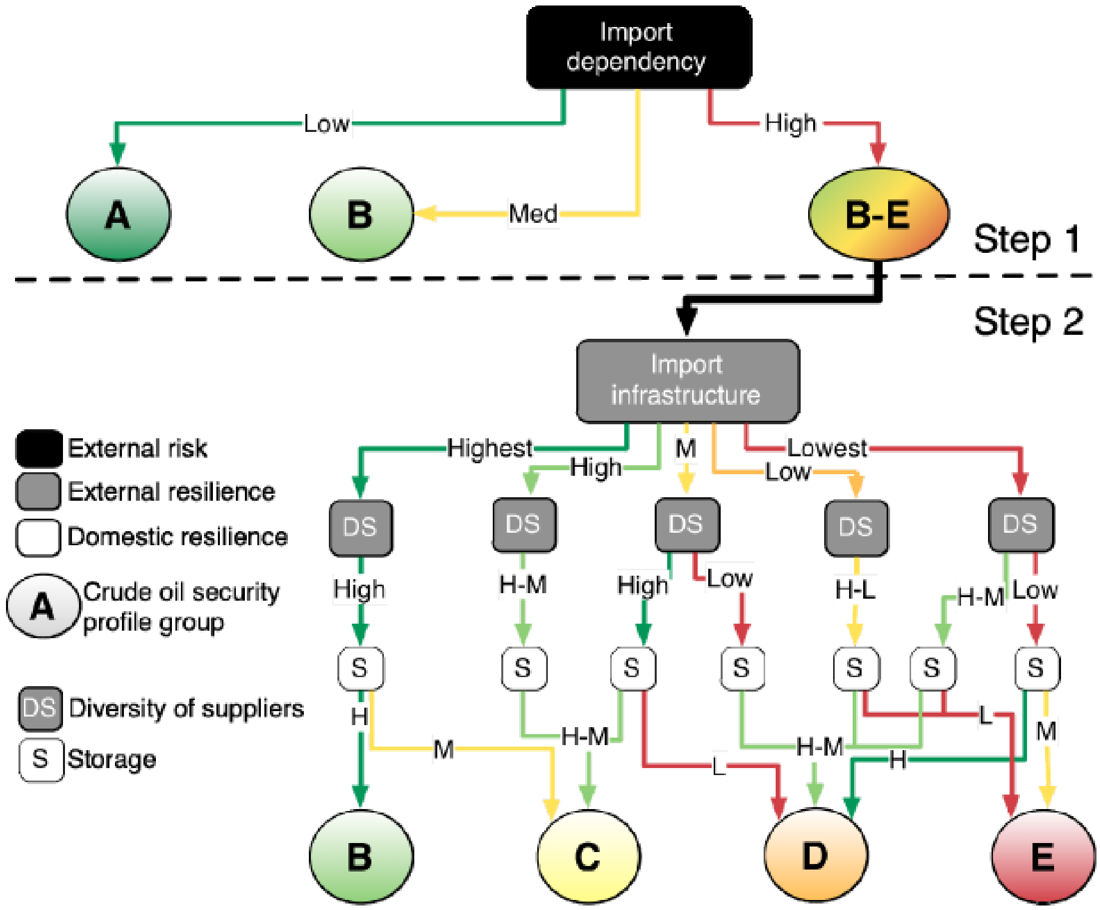
The average storage level is calculated by the average level of crude oil storage divided by maximum refinery intake. The Art. I, Sec. 7 of the Act nr. 218/2013 of the National Council of the Slovak Republic (EOSA, *Act*), based on Art.3, Sec. 1 of the European Council Directive 2009/119/EC (EU, *Council Directive 2009/119/EC)*, states that the reserve oil stocks will amount to at least 90 days of average daily net imports or 61 days of average daily inland consumption, whichever quantity is higher. Since the days of daily net imports are equal to days on inland consumption due to almost 100% dependence on imported oil, the first value is applicable.

Value: High (≥ 90 days)

Security profile: Crude oil

Fig. 5: Crude oil – steps for assessing security of supply

Figure 3 Crude oil: steps for assessing security of supply



Source: The IEA Model of Short-term Energy Security (MOSES), 2011

According to the assessment process described above, and by the scores previously given, Slovakia falls into the D category, having a Low crude oil supply security.

Value: D

Possibilities of improvement:

The scheme clearly considers import dependence to be the deciding factor, with all other indicators only smoothening the negative impact of the need to import oil. Since Slovakia has very few oil reserves, the solution lies not within reducing the percentage of imported oil, but within increasing the diversity of suppliers, and by opening new import routes via pipelines.

The best that Slovakia can achieve, based on the scheme above, is C category of crude oil supply security, with 3-4 ports and 5-8 pipeline entry points. It is assumed that anything above would not be economically viable for a small country like Slovakia. Regarding ports, by applying the selfish choice rule and the port rule, the two additional ports to which Slovakia could have functional access are Trieste, Italy and Gdańsk, Poland.

As discussed before, Trieste is theoretically accessible, but not viable. Its viability could be established by constructing a pipeline (so-called Bratislava-Schwechat Pipeline or BSP) between the refineries near Bratislava and Vienna, essentially connecting both Austrian and Slovak pipeline grids. The Schwechat refinery could get oil supplies from the Druzhba pipeline, and Slovakia would have access to oil traded from Trieste through TAL (Transalpine Pipeline) and supplied through AWP (Adria-Wien Pipeline).

In 2003, a project between the Austrian national oil and gas company OMV and Slovak oil TSO Transpetrol was initiated, with the intention of building this pipeline. Besides other reasons, the project cancelled due to a disapproval of the Slovak Ministry of Environment in 2005 – the Slovak part of the pipeline was planned too close to the most important freshwater reservoir in Slovakia (*Ropovod Bratislava-Schwechat,* bspipeline.eu). Currently, as mentioned before, BSP figures among the PCI approved by the European Commission, even though the implementation process hasn't even commenced (EC, *PCI 9.2*). If the pipeline would exist today, and if Slovakia would receive oil through TAL and AWP, Austria would have to give up pipeline capacity in favour of Slovakia. As of now, only extension of TAL figures among the PCI, which would complement the construction of BSP (EU, *2016/89,* pg. 18). If capacity and ecology issues were to be resolved, then BSP would become a viable project. Slovakia would then have a second accessible port and fourth point of entry.

The third port in Gdańsk and fifth point of entry on the Slovak-Polish border would fulfil the requirements set by the model for obtaining the High level of import infrastructure. This potential project is neither part of the Slovak energy policy, nor among the PCIs of the Commission. Its objective – to connect the northern and southern branch of the Druzhba pipeline, is intended to be solved by an extension of the Brody – Odessa (in Ukraine) pipeline to Adamowo, Poland. However, Ukraine is not a EU member country, and with current instability in the country, the Commission could be persuaded to change the path of the project towards the easternmost oil storage site of the Slovak part of Druzhba in Budkovce. The most important drawback to this project is its geographical length and lack of commercial reasons for launching it. Although Slovakia (and arguably Hungary as well) would profit from an additional port access, vast majority of the pipeline would go through Poland, and its costs would quite surely be significantly higher than benefits from access to southern Druzhba and pipelines connected to it. Therefore, this project would have to be perceived as a security project, aimed to alleviate pressure from other major EU pipelines in case of shortages. Costs of its construction (and possibly operation, due to possible future losses) would have to be borne by the EU via the CEF to a large extent. The pipeline would also allow access to the port in Odessa, where oil from the Caspian Sea region is traded. However, since Ukraine is not part of the EU, it does not fulfil the prerequisites of the port rule.

Another alternative, that was not included due to the selfish choice rule, could be a pipeline leading from Slovakia through Hungary to Romania and possibly Bulgaria, in order to have access to their ports. However, EU does not seem to prioritize this region for oil pipeline projects, since they can’t be found among the PCI. In addition, these ports serve primarily to import Russian oil to Romania and Bulgaria, which causes the pipeline to have no economic sense.

The model does not account for countries having a High import infrastructure and Low level of supply diversity. Slovakia thus needs to reach at least HHI equal to 0,8, which means that Slovakia would have to at least purchase oil from a single additional supplier to the extent of at least 11,27% of annual oil consumption. Note that this is the minimal extent in order to reach a higher level of supplier diversity; in reality, the percentage could be higher and divided among multiple suppliers or ports.

To sum up, according to MOSES, Slovakia would have to construct (together with respective neighbouring countries) a pipeline to Austria in order to have functional access to port in Trieste, a pipeline to Poland in order to have functional access to port in Gdańsk, and to supply at least 11,27% of annual oil consumption from a single additional supplier.

Potential value: C

3.3 Oil products

Tab. 6: Oil products balance (2015)

Oil products (2015)	**ktoe**	**TJ**
Primary products receipts	195	8 164
Gross refinery output	6 437	269 504
Refinery fuel	542	22 692
Import	1 655	69 291
Export	4 381	183 423
Change of stocks	-56	-2 345
Gross consumption	**3 308**	**23 629**

Source: Energy 2015, Statistical Office of the Slovak Republic

In contrast to the crude oil situation, Slovakia is a self-sufficient, net exporting country when it comes to its refining capabilities. The previous section *Crude oil* shows a map with both crude oil and oil products infrastructure. Slovakia has single refinery on the outskirts of Bratislava, owned by Slovnaft, a subsidiary of MOL Group, a Hungarian oil and gas company. The other refinery on the map, Petrochema Dubová, was insignificant in terms of produced quantity and was shut down in 2007. The grid consists of one internal pipeline stretching from the capital city to centre of the country, and one international pipeline heading towards Czech Republic, who is a net importer of Slovak oil products.

MOSES has identified the following indicators and range values for oil products:

Fig. 6: Oil products – indicators

Table 7 Oil products: indicators

	Risks	Resilience

External	**External risks:**
	• deficits:
	  ○ gasoline
	  ○ middle distillates
	  ○ other oil products
		External resilience:
		• entry points: ports
		• entry points: pipelines
		• entry points: rivers
		• diversity of suppliers

Domestic	**Domestic risks:**
	• crude oil supply vulnerability
	• number of refineries
		Domestic resilience:
		• flexibility of refining infrastructure
		• average stock levels (2010):
		  ○ gasoline
		  ○ middle distillates
		  ○ other oil products

Source: The IEA Model of Short-term Energy Security (MOSES), 2011

Fig. 7: Oil products – ranges for indicators

Table 8 Oil products: ranges for indicators

Dimensions	Indicator		Low		Medium	High
External risk	Deficit (gasoline/middle distillates/ other oil products)		<5%	5%-25%	25%-45%	≥45%
Domestic risk	Crude oil security profile		The five profiles evaluated in MOSES			
	Number of refineries		1		Indicator is only considered for countries with 1 refinery	
External resilience	Diversity of suppliers		≥0.54		0.18-0.54	≤0.18
	Import infrastructure (entry points)	Ports	0		2-4	≥5
		Rivers	1-2		No countries have more than 2 pipelines or river points without at least 5 maritime ports	
		Pipelines	1-2			
Domestic resilience	Flexibility of refining infrastructure (Nelson complexity index)		<6.0		6.0-9.0	≥9.0
	Average (2010) storage levels measured in weeks of forward demand		≤3	3-6	6-9	≥9

Source: The IEA Model of Short-term Energy Security (MOSES), 2011

<u>External risk: Deficit</u>

Deficit is a proportion of consumed oil products of imported origin. Even though Slovakia is a net exporter in total, out of 18 different oil products monitored by the Statistical Office of the Slovak Republic, three of them (lubricants, bitumen and petroleum coke) were imported in relatively small quantities, which are for the needs of this model overshadowed by exports of other oil products (such as motor gasoline and diesel oil). As a net exporter, the deficit falls in the category “very low”.

Value: Very Low (≤ 5%)

<u>Domestic risk: Crude oil security profile</u>

This value is the result of the evaluation done in the previous section.

Value: D

<u>Domestic risk: Number of refineries</u>

Slovakia has a single refinery in operation.

Value: Low (1 refinery)

<u>External resilience: Diversity of suppliers</u>

Not applicable for net exporters.

Value: N/A

External resilience: Entry points – ports, rivers, pipelines

Not applicable for net exporters.

Value: N/A

Domestic resilience: Flexibility of refining infrastructure

Calculated by the Nelson complexity index. For the Slovnaft refinery, its value is published by the owner, MOL Group (*Refining – Bratislava*).

Value: High (11,5)

Domestic resilience: Average storage levels measured in weeks of forward demand

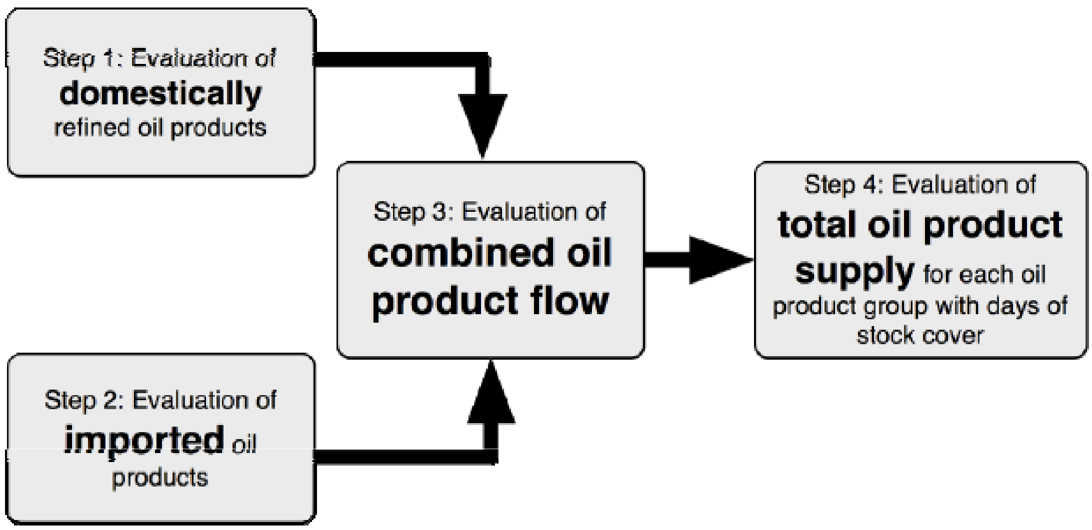
See "Domestic resilience: Average storage level" in section *Crude Oil*. The same laws apply for oil products, but in this case, the minimum stock level is equal to 61 days of forward demand, which is slightly below the 9-week cut-off level between medium and high storage level. However, since it is the lower end of the interval, both values will be used for evaluation.

Value: Medium-High (≥ 8,7 weeks)

Security profile: Oil products

Fig. 8: Oil products – steps for assessing security of supply

Figure 4 Oil Products: steps for assessing security of supply



Source: The IEA Model of Short-term Energy Security (MOSES), 2011

Step 1 consists of two stages. In the first stage, the vulnerability of domestically refined oil products is evaluated based on crude oil supply security and the flexibility of the refining infrastructure. According to MOSES, Slovakia's vulnerability with crude oil security belongs to category D and high refinery flexibility can be categorized as Medium (on a Very Low-Low-Medium-High-Very High scale).

The second stage includes the number of refineries, dividing the countries into two groups: those with a single refinery, and those with multiple refineries. Slovakia has only a single refinery for its domestic needs.

Value: Medium vulnerability with 1 refinery

Step 2 evaluates imported oil products. This step is only relevant for net importing countries, which makes it redundant for Slovakia. By being a net exporter, Slovakia automatically receives a Very Low vulnerability score for the purposes of the model.

Value: Very Low vulnerability

Step 3 combines both domestic and import flows of oil products and assigns them a single vulnerability value. The model differentiates between gasoline, middle distillates and other oil products. For all three groups, due to Slovakia's status of a net exporter across all three groups, the country falls into the Low vulnerability category.

Value: Low (gasoline), Low (middle distillates), Low (other oil products)

Step 4 identifies a security profile for each group of oil products. Gasoline security profile is B_2 (a subgroup of B), middle distillates also fall into the category B_2. Other oil products are hard to evaluate due to an inconsistency in the model related to the number of refineries. If we disregard the necessity of having at least two refineries, then other oil products lie within the C_1 security profile.

Value: B_2 (gasoline), B_2 (middle distillates), C_1 (other oil products)

<u>Possibilities of improvement:</u>

Slovakia fares much better when it comes to processing of oil, compared to importing it. The country has the possibility to reach the highest levels of oil product supply security, however there are two things that set it back and are reflected in the current security levels: low security of crude oil supply and a lack of a second refinery. Note that only of them is needed for gasoline and middle distillates security to reach the A group. As mentioned before, evaluation of other oil products is inconsistent in terms of wording, division of categories, and it differs from the first two oil product groups. For these reasons, it will not be further considered.

Tying in to the crude oil supply security, the security of oil product supply is directly linked to it, and its improvement would directly translate into a very high oil product supply security. However, as discussed, such a step would require EU-cooperation and significant investment. Building a second, minor refinery, e.g.: in the eastern part of the country, would only be a matter of Slovakia's decision-making. But since the Slovnaft refinery more than fulfils the needs of the country, there is arguably no economic justification of building a second refinery. The model shows that a small economy like Slovakia, even though its refining capacity might be stellar, is still inherently more vulnerable than large economies, who might have refineries on a lower level – but since they have multiple refining facilities, they are more resilient towards extraordinary events. Slovakia can only rely on other EU members to supply oil products in case of a prolonged incapability of the refinery to produce. In addition, the Slovak energy policy has no plans for any expansion of refining capacity.

To sum up, if Slovakia would follow the plan outlined in the *Crude Oil* chapter, the security oil products supply would reach the highest category.

Potential value: A (gasoline, middle distillates), other oil products not valued

3.4 Natural gas

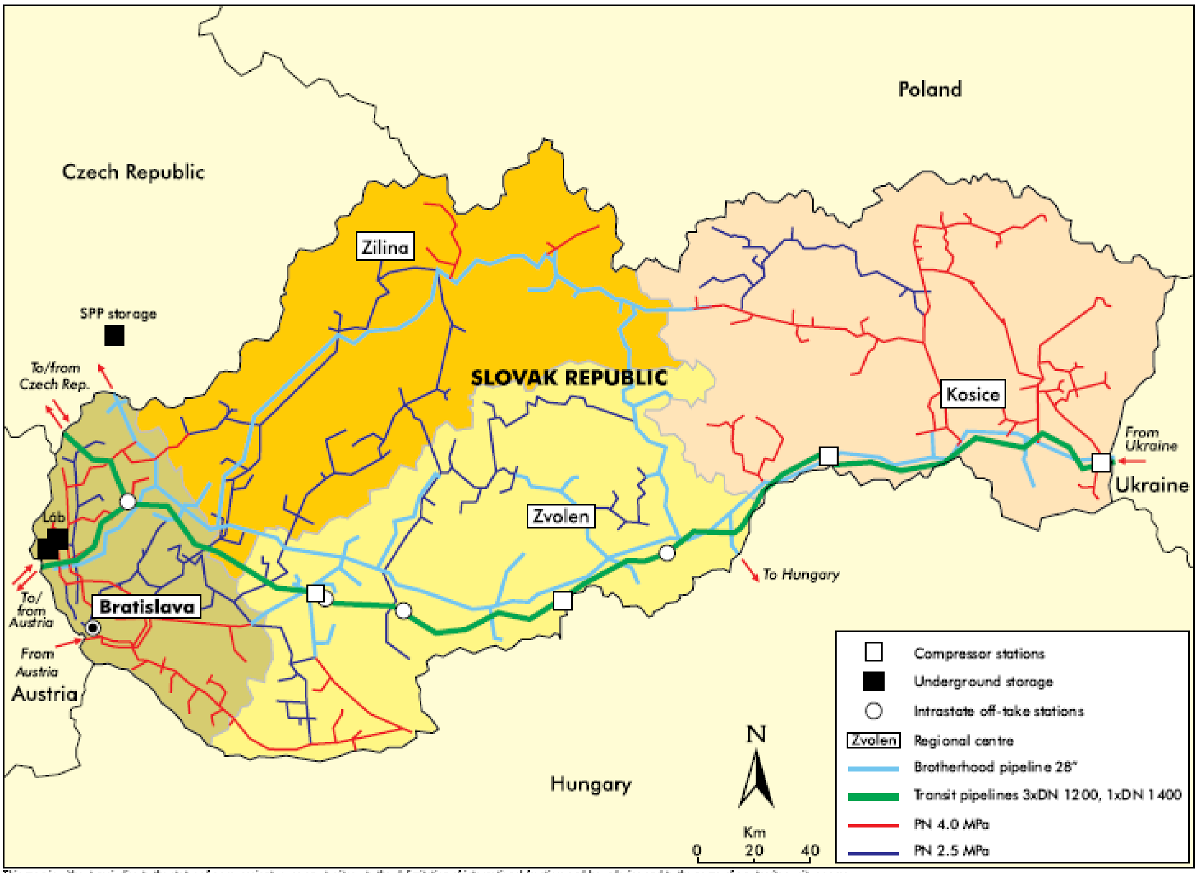
Tab. 7: Natural gas balance (2015)

Natural gas (2015)	**mcm**	**TJ**
Production	93	3 620
Import	4 407	171 542
Export	0	0
Change of stocks	139	5 310
Venting and flaring	5	195
Gross consumption	**4 639**	**180 472**

Source: Energy 2015, Statistical Office of the Slovak Republic

Fig. 9: Gas infrastructure of Slovakia

Map 4.23.2 Gas infrastructure of the Slovak Republic



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Source: Energy Supply Security 2014, International Energy Agency

Slovakia faces an analogous problem to natural gas supply security, as it does with crude oil – very limited own reserves and complete dependence on Russian supplies. The Brotherhood pipeline leads from Russia through Ukraine into Slovakia, where it branches out further to Hungary, Austria and Czech Republic. The entirety of imported gas is of Russian origin. Due to disagreements between Ukraine and Russia, Ukraine has completely stopped importing gas from Russia. In order to be able to import gas from other sources, Slovakia has enabled reverse flow along its section of the Brotherhood pipeline.

MOSES has identified the following natural gas supply security indicators and their value ranges:

Fig. 10: Natural gas - indicators

Table 15 Natural gas: dimensions of energy security and indicators

	Risks	Resilience
External	**External risks:** • import dependency • political stability of suppliers	**External resilience:** • entry points: Liquified natural gas (LNG) ports • entry points: pipelines • diversity of suppliers
Domestic	**Domestic risks:** • offshore production	**Domestic resilience:** • send-out capacity from natural gas storage • gas intensity

Source: The IEA Model of Short-term Energy Security (MOSES), 2011

Fig. 11: Natural gas – ranges for indicators

Table 16 Natural gas: ranges for indicators

Dimension	Indicator		Low	Medium	High
External risk	Import dependency		≤10%	30%-40%	≥70%
	Political stability of suppliers		<1.0	1.0-4.0	≥4.0
Domestic risk	Share of offshore production		≤30%	≥80%	
External resilience	Diversity of suppliers		>0.6	0.30-0.6	≤0.30
	Entry points	Ports	0	1-2	≥3
		Pipelines	1-2	3-4	≥5
Domestic resilience	Send-out capacity		<50%	50%-100%	>100%
	Natural gas intensity, bcm/$1000 USD		<20	20-60	>60

Source: The IEA Model of Short-term Energy Security (MOSES), 2011

<u>External risk: Import dependency</u>

In the same fashion as crude oil, Slovakia is subject to a near complete dependence on imported natural gas, given the lack of domestic reserves.

Value: High (98%)

<u>External risk: Political stability of suppliers</u>

As with crude oil, the same method of evaluation is used for natural gas supply. Since the only supplier is Russia, the calculation is, again, straightforward.

Value: High (4,00)

Domestic risk: Share of offshore production

Not applicable for Slovakia due to it being a landlocked country.

Value: N/A

External resilience: Diversity of suppliers

Since the only supplier is Russia, the diversity of supply is at the lowest extreme.

Value: Low (1,00)

External resilience: Entry points – ports, pipelines

Slovakia has no own LNG ports due to being landlocked, and even by applying the port rule it has no functional access to LNG ports in other EU countries, mostly due to insufficient infrastructure and pipeline capacity.

Entry points for pipelines are counted for every single place, where a gas pipeline crosses the national border. These are located at the border with Czech Republic, Austria, Hungary and Ukraine.

Value: Low (0 ports), Medium (4 pipeline entry points) – lower score is taken for evaluation

Domestic resilience: Send-out capacity

This indicator is measured by dividing the maximum drawdown rate from gas storage (both underground and LNG) by the peak daily demand.

According to IEA, in 2012, the maximum drawdown rate in Slovakia in 2012 was 39,25 mcm/day, whilst the peaky daily demand was 25 mcm/day (IEA, *Energy supply security 2014,* pg. 399-401). Even though the available data isn't completely up-to-date, there is no expectation that the drawdown rate would decrease due to a decrease in gas infrastructure, or that the daily demand would rise rapidly. On the contrary, gas consumption was at that time on a falling trend (IEA, *Energy supply security 2014,* pg. 399-401). We can safely assume for the purposes of this model that the send-out capacity is well over 100% at the moment, which lies in the highest value range.

Value: High (>100%)

Domestic resilience: Natural gas intensity

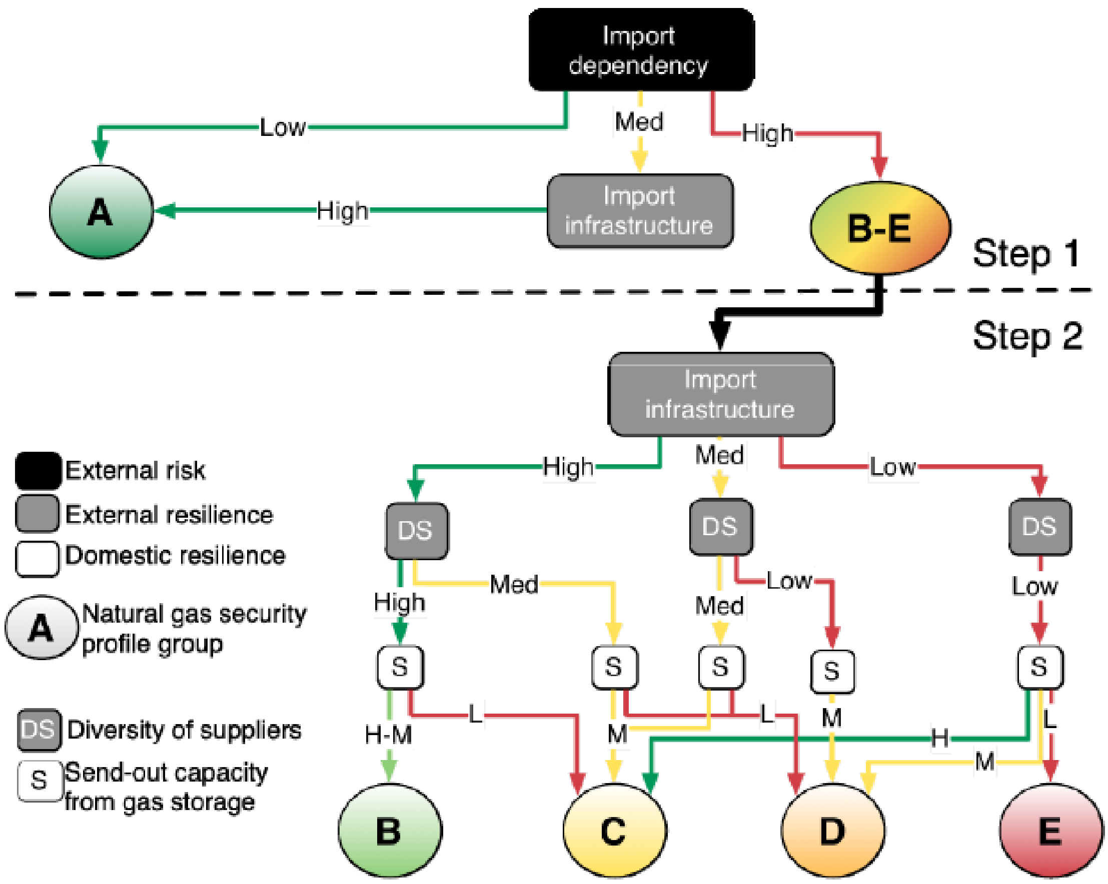
Natural gas intensity is calculated by dividing a country's consumption of natural gas (in cubic metres) by that country's GDP (in thousands of USD). This indicator may be distorted over time by fluctuations of the USD, and in addition the model does not mention, whether the GDP involved in calculation is nominal or real. For the calculation of this indicator, nominal GDP from year 2015 was used (*Slovakia – GDP*, worldbank.org).

Value: Medium (53,16 m^2/1000 USD)

Security profile: Natural gas

Fig. 12: Natural gas – steps for assessing security of supply

Figure 5 Natural gas: steps for assessing security of supply



Source: The IEA Model of Short-term Energy Security (MOSES), 2011

According to this assessment process, Slovakia's natural gas supply security falls into the C category.

Value: C

Possibilities of improvement:

As with crude oil, the task is not to diminish import dependence (due to lack of own reserves), but to diversify sources of natural gas. Two problems that cause the low rating are the non-existent diversity of suppliers and lack of necessary gas infrastructure, especially regarding access to LNG ports.

First task is to find access to at least three LNG ports, and to have one more entry point created by a new pipeline. The PCIs approved by the Commission manage to solve both issues. The Slovak-Polish gas interconnector, together with the expansion of Polish gas infrastructure and construction of the Polish-Lithuanian interconnection, would enable Slovakia to have a fifth entry point on the Polish-Slovak border, and access to LNG ports in Świnoujście, Poland and Klaipėda, Lithuania (also known as Independence). The other PCI, on which Slovakia is directly taking part, is the *Eastring* project – a gas pipeline that would flow from Slovakia's eastern part of Brotherhood pipeline through Hungary, Romania and Bulgaria, which would connect a large part of CEE region to the Turkish gas grid. It is, however, not the only PCI with this goal in mind. The BRUA transmission corridor, Austria-Bulgaria pipeline system, and Austria-Greece pipeline known as *Tesla* are all in competition against Eastring since they fulfil the same goals (EU, *2016/89*). Even though they are PCIs, it cannot be expected from the EU to support duplicitous infrastructure building. Since "Eastring" would increase Slovakia's importance as a gas transit country, it is in its interest to lobby for its completion. From the model point of view, it would create a sixth entry point, but no additional access to an LNG port, that would fulfil the port rule requirements. The last, third LNG port needed could actually become available without Slovakia's involvement – an LNG terminal in Omišalj, Croatia is planned to be built within the next couple of years, with the intention of supplying nearby countries in the CEE region.

Along with the expansion of infrastructure, raising the level of supply diversity is the next logical step. Non-Russian gas is already available in North Sea via pipeline transit through Germany and Czech Republic, and major LNG traders such as Qatar, Algeria or Nigeria, but also US and Canada can become new suppliers of gas via LNG terminals in Baltic and Adriatic Sea. If Slovakia would gain access to Turkish gas infrastructure, it could purchase pipeline gas from major exporters such as Azerbaijan, Turkmenistan or Iran. If we follow the value ranges for supply diversity, the HHI would have to fall below 0,6, in order for it to reach Medium level. This means that the share of Russian gas on total imported gas must be less than 72,36%, with at least one additional supplier. This is a realistic goal, already achieved by e.g.: Czech Republic, in their case by simply importing gas from Norway (*Eurostat*).

The assessment flowchart here is inconsistent, since a Low infrastructure, Low diversity of suppliers and High send-out capacity country (which Slovakia is now) is given the same rating as a High infrastructure, Medium diversity and High send-out capacity (which Slovakia could be after proposed improvements). In this particular case, it would be more sensible to focus on improvements of indicators than the whole rating.

To sum-up, the Polish-Slovak interconnector is the only gas project that seriously improves Slovak energy security, as it provides alongside other PCIs access to two LNG ports in Poland and Lithuania. The third LNG port in Omišalj will be available in time, outside of Slovakia's scope of influence. The Eastring project is more significant for other participating countries than Slovakia in terms of energy security, although it would also bring economic benefits to Slovakia. At least 27,64% of annual gas consumption should be from at least a single difference source than Russia.

3.5 Coal

Tab. 8: Coal balance (2015)

Coal (2015)	kt
Production	3637
Import	4317
Export	63
Change of stocks	158
Gross consumption	**8049**

Source: Energy 2015, Statistical Office of Slovak Republic; Note: Export of 62 kt of coal tar, which is not part of the Slovak consumption of coal, is not reflected in the total gross consumption.

The Statistical Office measures values for eight different types of solid fossil fuels or coal – anthracite, coking coal, other bituminous coal, brown coal and lignite, patent fuel, coke oven coke, coal tar and brown coal briquettes.

In Slovakia, only brown coal, coke oven coke and coal tar are being produced. The domestically mined quantity is insufficient and at this point, all types of coal are being imported, except coal tar, which is not used in Slovakia and is produced only for exporting purposes. Coal tar comprises an overwhelming majority of otherwise insignificant Slovak coal exports.

MOSES has identified the following indicators and their value ranges:

Fig. 13: Coal - indicators

Table 21 Coal: dimensions of energy security and indicators

	Risks	Resilience
External	**External risks:** • import dependency	**External resilience:** • entry points • diversity of suppliers
Domestic	**Domestic risks:** • proportion of underground mining	**Domestic resilience:** • n/a

Source: The IEA Model of Short-term Energy Security (MOSES), 2011

Fig. 14: Coal – ranges for indicators

Table 22 Coal: ranges for indicators

Dimension	Indicator		Low	Medium	High
External risk	Import dependency		0%	30%-70%	>70%
Domestic risk	Share of underground mining		<40%	40%-60%	No countries have more than 60% of their domestic coal from underground sources
External resilience	Diversity of suppliers		>0.6	0.3-0.6	<0.3
	Import Infrastructure (entry points)	Sea or river ports	1-2	3-4	>5
		Railways	2-3	No countries have >3 railway entry points and <3 sea or river ports.	

Source: The IEA Model of Short-term Energy Security (MOSES), 2011

External risk: Import dependence

Import dependence is calculated in the same fashion as with other sources of energy. 62 kilotons of exported coal tar are excluded from the calculation, since the Slovak economy does not depend from its consumption.

Value: Medium (53,62%)

Domestic risk: Share of underground mining

From the three types of coal produced here, only the entirety of brown coal is mined underground.

Value: Medium (53,31%)

External resilience: Diversity of suppliers

Analogously to other energy sources, it is calculated as a Herfindahl-Hirschman Index of all suppliers.

Value: High (0,22)

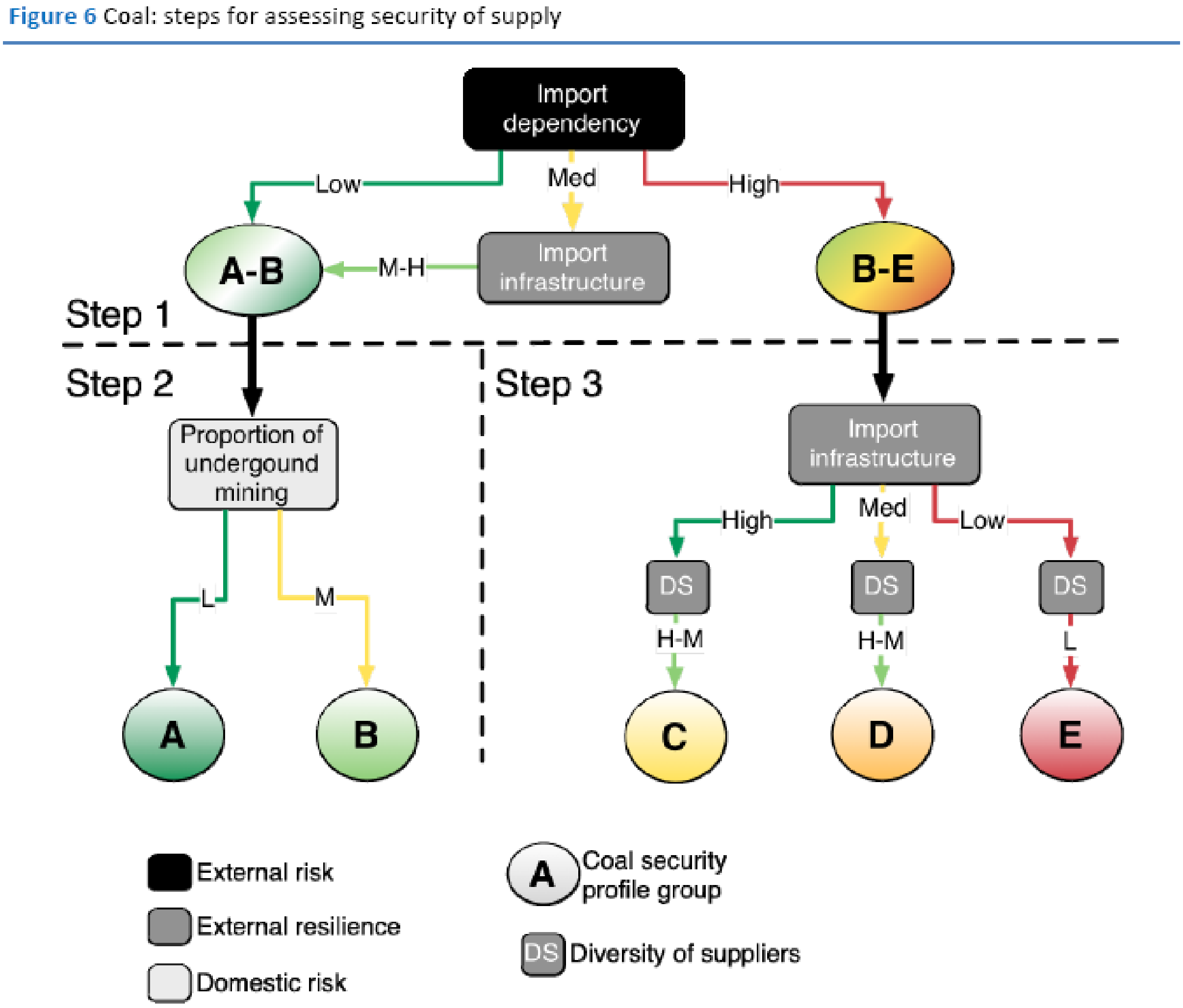
External resilience: Entry points – sea/river ports, railways

Slovakia has access to two commercially used river ports on the river Danube in Bratislava and Komárno (*Transshipment*, spap.sk). It also has six major railway connections with its neighbours and several other minor ones (*Eurail map)*. By applying the port rule, Slovakia has connection to multiple sea ports in Poland alone, but also other seaside EU member countries.

Value: High (>5 ports, 6 railways)

Security profile: Coal

Fig. 15: Coal – steps for assessing security of supply



Source: The IEA Model of Short-term Energy Security (MOSES), 2011

The flowchart places Slovakia to the B security profile group, with Medium proportion of underground mining being the only factor separating it from the highest category.

Value: B

Possibilities of improvement:

If we strictly follow the structure of the assessment scheme, the only factor that deprives Slovakia of belonging to the highest category is the proportion of underground mining, which should be below 40%. This could be offset by importing coal (without exceeding the 70% import threshold), replacing coal with gas in CHP plants, or producing more electricity via nuclear plants. However, the gross energy consumption forecast shown in Chapter 2.1 clearly shows, that coal consumption will decrease by around 27%, which leaves ample space for decreasing the proportion of underground mining by simply reducing the consumption of coal mined underground, since its much higher than 13,31% of production reduction needed to fulfil this condition.

Arguably, Slovakia's coal mining is reaching its zenith. The state subvention of coal mining business has reached a point, where the subvention of a single workplace is twice as high than the wage of a miner (Institute of Financial Policy, 2011). This is due to political and welfare reasons, since entire regions would be struck by a huge spike in unemployment and emigration, due to lack of other employment opportunities. However, the government is pursuing a policy of utilizing coal for commercial and industrial purposes until at least 2035 (MESR, *Energy Policy,* pg. 47).

From the model point of view, the future reduction of consumption will be sufficient, as long as the proportion of underground mining is decreased below the 40% threshold.

Potential value: A

3.6 Biomass and waste

Tab. 9: Biomass and waste balance (2015)

Biomass and waste (2015)	**TJ**
Production	51644
Import	40
Export	476
Change of stocks	30
Gross consumption	**51238**

Source: Energy 2015, Statistical Office of Slovak Republic

The Statistical Office collects data for the following biomass and waste sources of energy (excluding biofuel): industrial wastes, municipal solid wastes (both renewable and non-renewable), solid biomass (wood/wood wastes/other solid wastes) and biogases. Solid biomass comprises about 70% of gross consumption and 100% of export. Slovakia is self-sufficient across all previously mentioned sources of energy except industrial wastes, where there is a slight net import.

MOSES identifies the following indicators and value ranges:

Fig. 16: Biomass and waste – indicators

Table 25 Biomass and waste: dimensions of energy security and indicators

	Risks	Resilience
External	**External risks:** • import dependence	**External resilience:** • n/a
Domestic	**Domestic risks:** • n/a	**Domestic resilience:** • diversity of sources

Source: The IEA Model of Short-term Energy Security (MOSES), 2011

Fig. 17: Biomass and waste – ranges for indicators

Table 26 Biomass and waste: ranges for indicators

Dimension	Indicator	Low		Medium	High
External risk	Import dependence	<15%	15%-25%	No country imports more than 25% of this source	
Domestic resilience	Source diversity	>0.5		0.3-0.5	<0.3

Source: The IEA Model of Short-term Energy Security (MOSES), 2011

External risk: Import dependence

In total, Slovakia is a net exporter of biomass and waste.

Value: Very Low (0%)

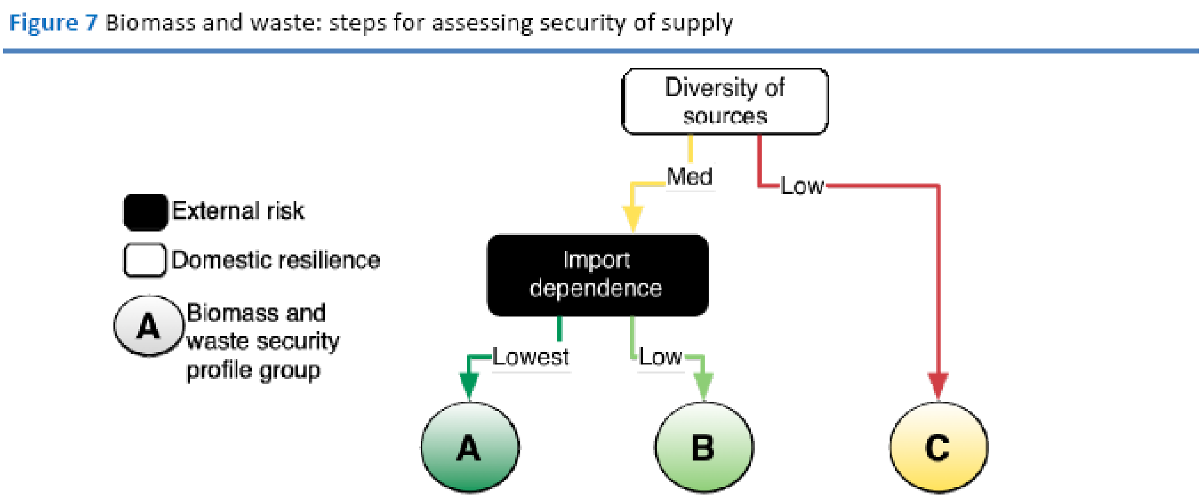
Domestic resilience: Diversity of sources

Contrary to previous indicators of diversity, this one measures the diversity of inland sources of biomass and waste. Slovakia has a Low rating due to a prevalence of wood in the biomass mix.

Value: Low (0,54)

Security profile: Biomass and waste

Fig. 18: Biomass and waste – steps for assessing security of supply



Source: The IEA Model of Short-term Energy Security (MOSES), 2011

Following the assessment scheme above, Slovakia belongs to the lowest C category, due a to low diversity of internal sources, i.e. relative overdependence on wood. A more effective utilization of wastes would place Slovakia in the A category. This is however related to energy efficiency, not to energy security, and will not be further considered.

Value: C

Potential value: A

3.7 Biofuels

Tab. 10: Biofuels balance (2015)

Biofuels (2015)	kt
Production	218
Imports	111
Exports	133
Change of stocks	0
Gross consumption	**195**

Source: Energy 2015, Statistical Office of Slovak Republic

Just as oil products were evaluated separately from crude oil security, so are biofuels evaluated separately from biomass and waste as a secondary source of energy.

MOSES identifies the following indicators and value ranges:

Fig. 19: Biofuels - indicators

Table 27 Biofuels: dimensions of energy security and indicators

	Risks	Resilience
External	**External risks:** • import dependence	**External resilience:** • entry points
Domestic	**Domestic risks:** • volatility of agricultural output	**Domestic resilience:** • n/a

Source: The IEA Model of Short-term Energy Security (MOSES), 2011

Fig. 20: Biofuels – ranges for indicators

Table 28 Biofuels: ranges for indicators

Dimensions	Indicator		Low	Medium	High
External risk	Import dependence		<20%	40%-70%	>80%
External resilience	Import infrastructure (entry points)	Sea ports	0	2-4	≥5
		River ports	1-2	No countries have more than 2 river entry points without at least 5 maritime ports	
Domestic risk	Volatility of agricultural output		0%-5%	5%-10%	>10%

Source: The IEA Model of Short-term Energy Security (MOSES), 2011

<u>External risk: Import dependence</u>

Slovakia is a net exporter of biofuels.

Value: Low (0%)

External resilience: Entry points – Sea/river ports

Same as in the *Coal* subchapter, the port rule states that Slovakia has functional access to more than five sea ports.

Value: High (≥ 5 sea ports)

Domestic risk: Volatility of agricultural output

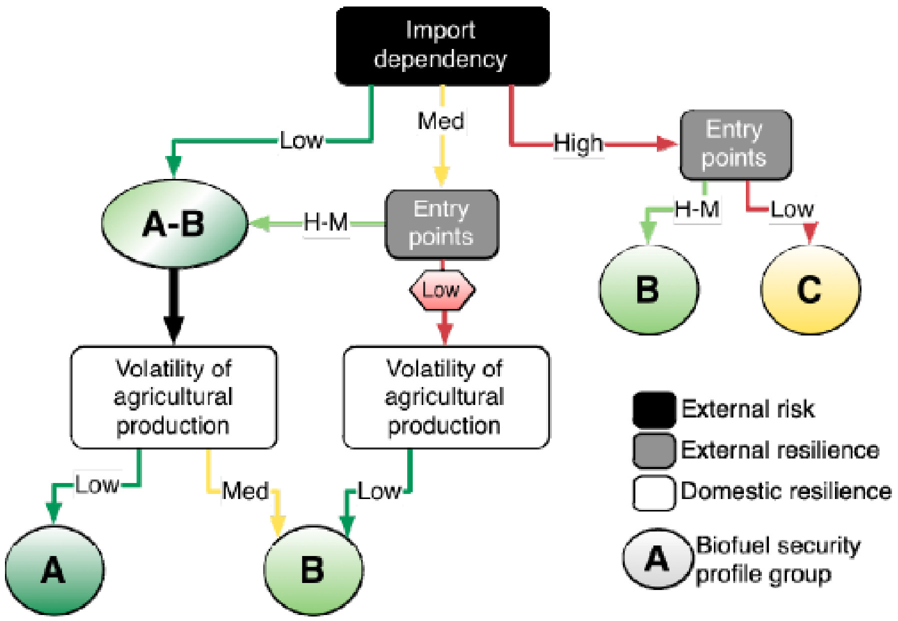
Due to lack of official data on volatility of biofuel production, the value range used for the 2011 version of the model will be used.

Value: Medium (no specific value)

Security profile: Biofuels

Fig. 21: Biofuels – steps for assessing security of supply

Figure 8 Biofuels: steps for assessing security of supply



Source: The IEA Model of Short-term Energy Security (MOSES), 2011

According to the assessment scheme above, Slovakia belongs to the B category.

Value: B

Possibilities of improvement:

The only real downside in terms of current biofuels supply is the volatility of agricultural production, whose improvement lies beyond the possibilities of national energy policy. As Slovakia is a net exporter of biofuels, their supply can be considered secure.

Potential value: B

3.8 Hydropower

In 2015, a total of 6 337 GWh of electricity was produced in Slovakia, from which more than 72% percent was used for public purposes, while the rest was used by factories and other production units. Around 2% of the Slovak energy supply stems from hydropower, which is about one quarter of all renewable energy.

MOSES identifies only a single indicator for hydropower. The author of the model admits that more indicators should be included, e.g.: drought frequency, severity and duration, but it's not possible due to lack of comparable data across all IEA member countries.

Fig. 22: Hydropower – indicators

Table 34 Hydropower: indicators for evaluating vulnerability

	Risks	Resilience
External	External risks: • n/a	External resilience: • n/a
Domestic	Domestic risks: • variability of hydropower (as measured by annual volatility of production)	Domestic resilience:

Note: The variability of hydropower is considered to be a measure of both risk and resilience (see text).

Source: The IEA Model of Short-term Energy Security (MOSES), 2011

Domestic risk/resilience: Variability of hydropower

This indicator is calculated as the standard deviation of yearly production divided by the average yearly production for years 2005-2015. Slovakia's variability (also called volatility in the model) of hydropower production was 8,77% for the above period (*SOSR database*).

Value: 8,77%

Security profile: Hydropower

Fig. 23: Hydropower – security profiles

Table 35 Hydropower: security profiles

Group	Countries with:
A	Volatility of hydropower production ≤11%.
B	Volatility of hydropower production 12%-21%.
C	Volatility of hydropower production ≥22%.

Source: The IEA Model of Short-term Energy Security (MOSES), 2011

Value of the single indicator falls into the lowest range below 11%. This makes Slovakia's supply of hydropower belong to the A category.

Value: A

<u>Possibilities of improvement:</u>

Slovakia has fulfilled the only requirement according to MOSES in order to be placed in the highest category. No other improvements are needed.

Potential value: A

3.9 Nuclear power

Nuclear power produced a net amount of 14 081 GWh of electricity and 1 529 TJ of heat in 2015. Although the heat production pales in comparison to combustible fuels, almost 55% of electricity is produced by nuclear plants. Four nuclear reactors are currently in operation (two each in Jaslovské Bohunice and Mochovce in western Slovakia), with two more being under construction at the Mochovce power plant (IAEA, *Country Profiles – Slovakia,* Table 7). Both reactors in construction are very close to completion (*Mochovce 3&4,* seas.sk).

MOSES identifies the follow indicators and value ranges:

Fig. 24: Nuclear power – indicators

Table 36 Nuclear power: dimensions of energy security and indicators

	Risks	Resilience
External	**External risks:** • n/a	**External resilience:** • n/a
Domestic	**Domestic risks:** • unplanned outage rate • average age of nuclear power plants	**Domestic resilience:** • diversity of reactor models • number of nuclear power plants

Source: The IEA Model of Short-term Energy Security (MOSES), 2011

Fig. 25: Nuclear power – ranges for indicators

Table 37 Nuclear power: ranges for indicators

Indicator		Low	Medium	High	
Domestic risk	Unplanned capability loss factor	<3%	3%-6%	6%-9%	>15%
	Average age of NPPs	<20	20-30	>30	
Domestic resilience	Nuclear power reactors	1	4-10	≥15	
	Diversity of reactor models	>0.6	0.3-0.6	<0.3	

Source: The IEA Model of Short-term Energy Security (MOSES), 2011

Domestic risk: Unplanned outage rate

This indicator is reported by the International Atomic Energy Agency (IAEA), and it is measured as unplanned energy losses for a given period divided by the reference energy generation for that period, i.e. it measures the unplanned time, during which a power-plant is offline. Due to unavailability of national data for security reasons, an estimate of Slovak unplanned outage rate was calculated using IAEA data from 2009-2015. 2009 was the first year after decommissioning of nuclear reactor Bohunice-2, thus being the first year with only 4 reactors in operation. IAEA publishes outage statistics for types of reactors, not specific reactors. Since all Slovak reactors are of the same type, the reactor type outage rates and number of hours lost per reactor type can be applied for calculation of the national outage rates (IAEA, *Nuclear Power Reactors 2016*, pg. 60).

Together with global hours lost per GWh lost ratio (IAEA, *Nuclear Power Reactors 2016*, pg. 31), and national data on electricity production, the unplanned outage rate was estimated to be 5,19%, which falls under the Medium risk value range.

Value: Medium (5,19%)

Domestic risk: Average age of nuclear power plants

The age of power plants that are fully operational at year 2015 is being considered. The start of commercial use is chosen as the beginning of a nuclear plant's age, which is calculated from its' oldest reactor in operation (IAEA, *Country Profiles – Slovakia,* Table 7).

Value: Medium (23,5 years)

Domestic resilience: Diversity of reactor models

Diversity is measured as a HHI of total generation capacity of each type of reactor model. This means that if only one type of reactor model is used in an economy for any number of reactors, the value of index will always be 1. This indicator account for possibility of technical flaws within a reactor model that could lead to a shutdown.

All operational and under construction reactors in Slovakia are the same model (VVER V-213), which results in a Low diversity of reactor models (IAEA, *Nuclear Power Reactors 2016*, pg. 31, 41-42).

Value: Low (1.00)

Domestic resilience: Number of nuclear power reactors

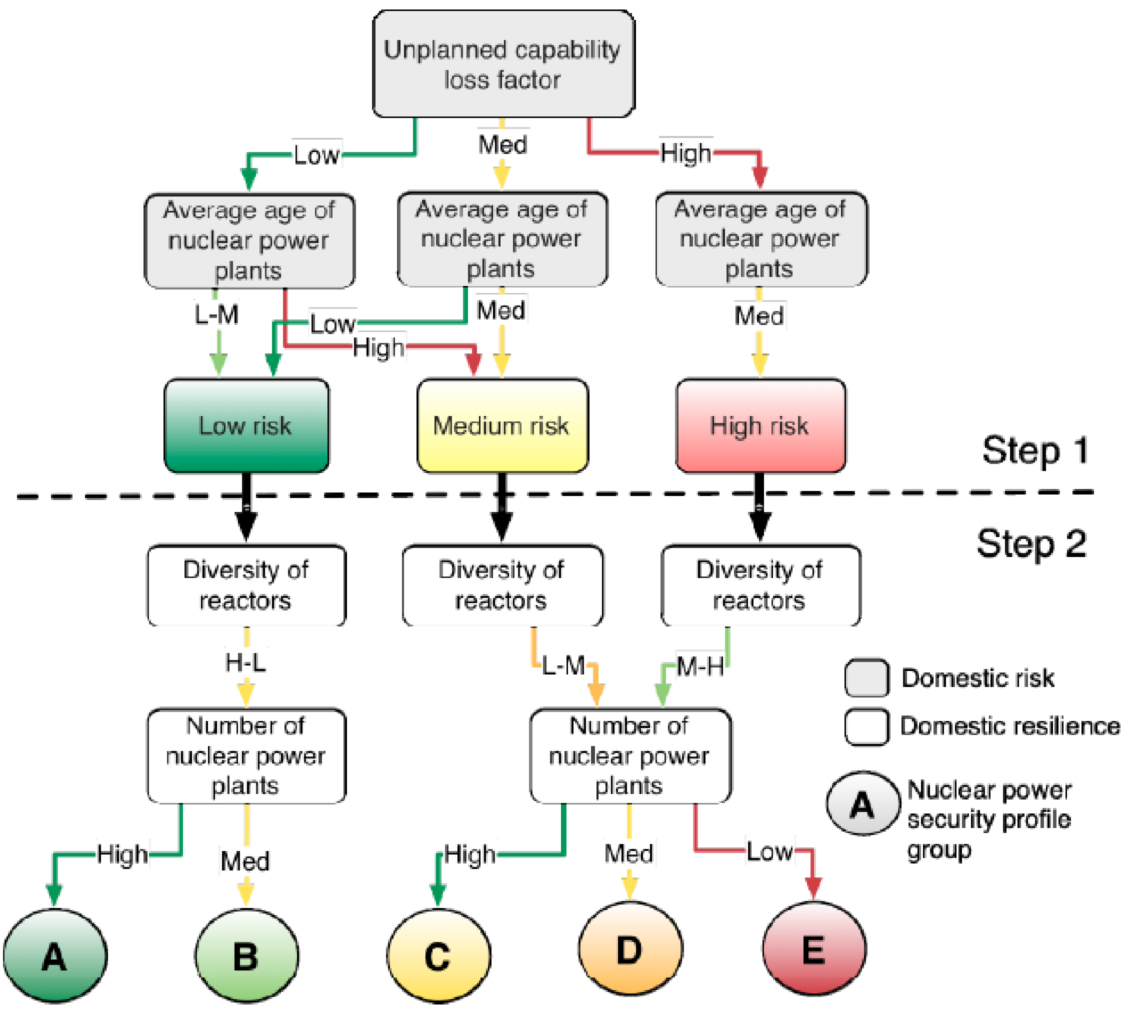
The description of this indicator in MOSES is inconsistent, as it mixes up the terms “power plants” and “reactors”. Since the indicator range considers “reactors” for the evaluation, the number of reactors will be the value included in the assessment.

Value: Medium (4 nuclear reactors)

Security profile: Nuclear energy

Fig. 26: Nuclear power – steps for assessing security of supply

Figure 9 Nuclear power: steps for assessing security of supply



Source: The IEA Model of Short-term Energy Security (MOSES), 2011

Using the flowchart above, Slovakia's security of nuclear energy supply belongs to the D category.

Value: D

Possibilities of improvement:

If we follow the assessment scheme, we see that if either the unplanned outage rate falls below 3%, or that the average age of nuclear reactors falls below 20 years, then Slovakia would reach the B category. If the construction of the two reactors in Mochovce finishes at the end of the year, the average age of all six reactors would be 19 years.

The government plans to construct a new nuclear plant in order to replace the remaining reactors in Jaslovské Bohunice, with capacity of either 1 x 1200 MW, 2x 1200 MW or 1 x 1700 MW, planned to be commissioned in 2025. It is also considering extending the lifespan of current reactors at Jaslovské Bohunice until 2045. If both plans will be realized, the average age of reactors in year 2030 (the final year energy security planning) will be 23,25 years. If the government decides to decommission the oldest two reactors in Jaslovské Bohunice, the average age of reactors will be 16 years. An average age under 20 years ensures, that Slovakia stays in B category, unless the capability loss is above 6%.

To sum up, a construction of a new nuclear plant in Jaslovské Bohunice, decommissioning of the old reactors at the same place, and finalizing new reactors in Mochovce will ensure, in case of unplanned outages staying below 6%, that Slovakia’s nuclear energy supply security in year 2030 will reach the highest level for an economy of this size.

Potential value: B

4 Model scenario

MOSES as a model served to highlight Slovakia's various shortcomings in its energy supply security. It analysed individual sources of energy, with energy security being the only goal in mind. The results derived from the model will be implemented in the model scenario. A scenario is understood as a set of measures that is meant to achieve a set of goals. After the measures have been determined, an estimated financial cost will be assigned to each measure. The measures are meant to be implemented from 2018 to 2030. Based on the measure costs and the time constraints, a budgetary plan will be suggested for each year. As a final note, possibilities of financing these plans will be discussed, given the financing options that we know are available.

The model scenario includes only those measures, that are strictly related to results of MOSES, with a single goal of improving energy security.

4.1 Measures for the model scenario

Analysis of individual energy sources in Chapter 3 yielded a range of possible improvements for areas that require them. Each measure will be listed with an estimated construction cost of their implementation and possibilities of financing.

Following is the full list of model scenario measures derived from the results of the model:

1. Crude oil – Bratislava-Schwechat Pipeline (BSP)

In the model, the model provides an additional entry point and port access. The Slovak energy policy paper estimates the costs of the project to be in range of 75-125 mil. € (MESR, *Energy Policy,* pg. 47). The project is part of the PCIs, and although the CEF funds do not provide support for oil projects, it is still eligible for EU funding from other sources. The company that plans to construct the pipeline is 74% owned by Slovak oil TSO (100% owned by Slovakia) (*bspipeline.eu*). The project has not started yet due to unresolved capacity and environmental issues.

2. Crude oil – Slovakia-Poland oil pipeline

The pipeline, drafted for the purposes of this paper, is meant to be an alternative to Polish-Ukrainian pipeline between Brody, Ukraine and Adamowo, Poland. Therefore, its features will serve as a rough estimate for its potential Slovak-Polish variant. The estimated price of the pipeline is 356 mil. € - it should be understood as an indicative price for the Slovak-Polish variant, whose real price may diverge significantly (EC, *State aid – Poland,* currency rate used: 2013, March 06). The company, that plans to build this pipeline is originally a consortium owned by state oil companies of Poland, Ukraine, Lithuania, Georgia and Azerbaijan (*Sarmatia – Mission*, sarmatia.pl). It is speculative to predict, what would be the ownership structure of a consortium wanting to build a Slovak-Polish pipeline. Using the selfish choice rule, it is assumed that the pipeline will be built by a Slovak-Polish company, where both countries hold a 50% share. It is also assumed that the project would be a PCI, therefore eligible for non-CEF EU funding. The pipeline would assure access to an additional port and it would create an entry point on the Slovak-Polish border. The project is designed for the purposes of the thesis; therefore, its planning would start sometimes during the following years.

3. Natural gas – Slovakia-Poland gas interconnector

This interconnector creates an entry point and allows access to two LNG ports. The Slovak policy paper estimates, that the Slovak share of costs will be around 142 mil. € (MESR, *Energy Policy*, pg. 55). The project is eligible for EU funding by being listed among the PCIs. The promoters of the pipeline are Slovak and Polish gas TSOs. The project has already received a grant for EU funding, and is expected to be finished by 2021 (Eustream, *Prepojovací plynovod*).

4. Nuclear power – New NPP Bohunice

The new NPP is a necessary requirement for keeping the average age of nuclear reactors under 20 years by 2030, and by consequence to lower the risk of unplanned outages. Estimated cost of construction is 4-6 bil. € (*Nová atómka v Bohuniciach*). The Slovak government owns a 51% share of the company commissioned with the construction. The project has already passed environmental impact assessment (EIA) by the Slovak government, and the operation of the first reactor is expected be reached after 2025 (*Feasibility study – Schedule,* jess.sk).

The change of shares of non-Russian oil and gas does not feature among the measures. It is assumed, that prices of oil and gas will eventually converge towards EU prices, and that Slovakia will be able to purchase both commodities for market prices, instead of being bound by long term contracts with disadvantageous prices. At that point, after constructing the additional pipelines, the exact share of non-Russian gas will ultimately be a matter of political will.

4.2 Budget proposal

Tab. 11: List of model scenario projects

Project	Est. costs (SK)	EU funding	Project phase	Est. year of completion
BSP	55,5-92,5 mil. €	available	not started	not available
SK-PL oil pipeline	173 mil. €	available	not started	not available
SK-PL gas pipeline	142 mil. €	granted	permit granted	2021
New NPP Bohunice	2000-3000 m. €	not available	EIA passed	after 2025

The estimated costs column shows investment costs that will need to borne by the Slovak government via its shares in the investing company. The costs are shown before EU funding – the only confirmed funding is granted to the SK-PL gas pipeline in the amount of 57 mil. €, which makes Slovak contribution worth 85 mil. € (Eustream, *Prepojovací plynovod*).

After having summarized all cost items, the goal is to allocate projects within the 2018-2030 timeline in such a manner that minimizes spikes in the yearly costs borne by the Slovak budget. Based on the SK-PL gas pipeline information, it is assumed that both SK-PL pipeline projects will take 3 years to construct, and that the BSP will take 2 years, due to the project's shorter geographical length. Based on the construction of the two new blocks at NPP Mochovce, it is assumed that the construction of the new NPP Bohunice will take 8 years (*Mochovce 3&4,* seas.sk). For the purposes of budget planning, the costs of projects will be divided evenly among the years of their construction. For the crude oil pipelines, the earliest year of their construction may be 2022, due to all pre-construction processes needing 4 years to be finished, as it was in the case of PL-SK gas pipeline. The NPP has already undergone an EIA, which leaves only paperwork related to construction permits to be completed. It is assumed that those will take 3 years to be finished.

Tab. 12: Costs and construction time of model scenario projects

Project	Construction time	Costs per year	Earliest year of construction
BSP	2 years	27,75-46,25 mil. €	2022
SK-PL oil pipeline	3 years	57,66 mil. €	2022
SK-PL gas pipeline	3 years	28,33 mil. €	2018
New NPP Bohunice	8 years	250-375 mil. €	2021

With costs per year and construction periods determined, an example budget may be compiled. Two versions of them will appear here – one that takes into account the lower end of the cost intervals, and one that takes the upper end.

Fig. 27: Slovak energy security budget – lower interval (in mil. €)

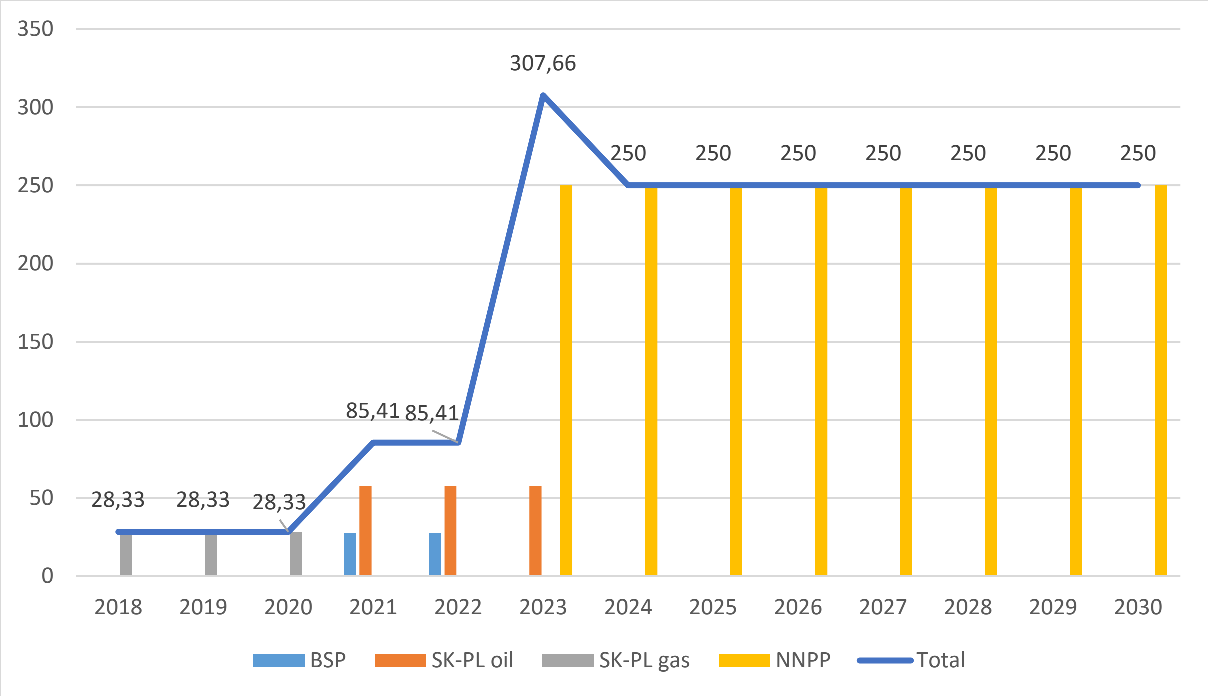
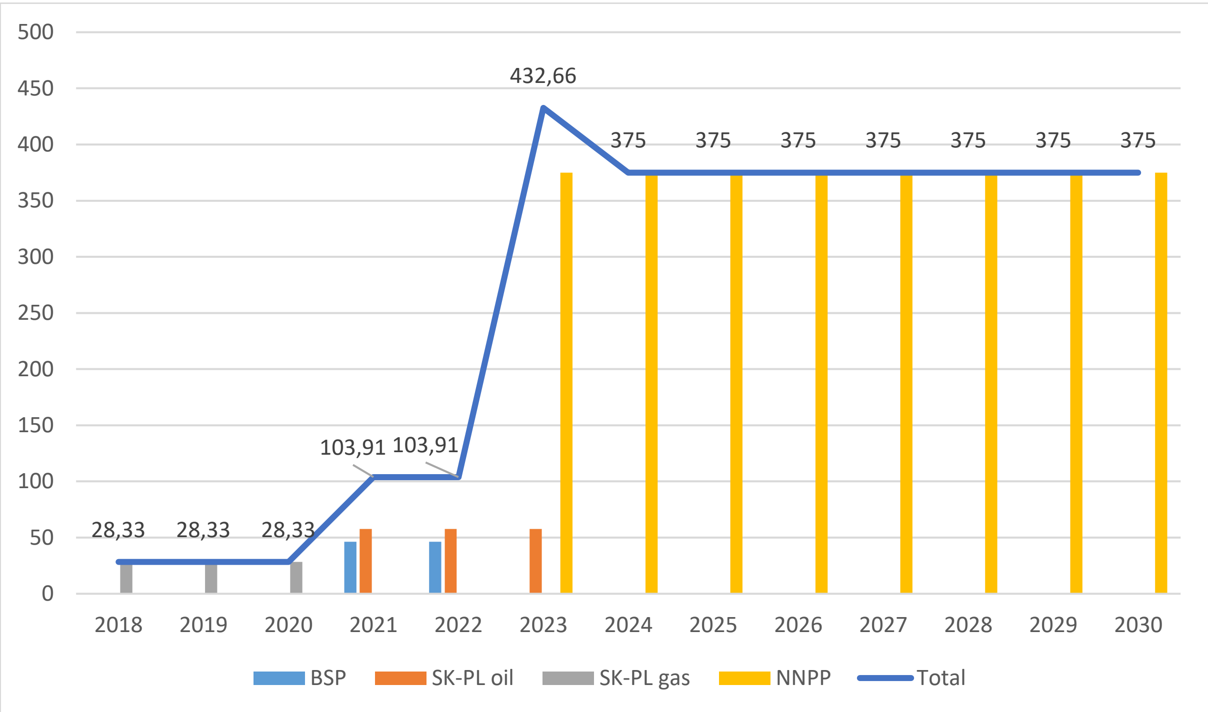


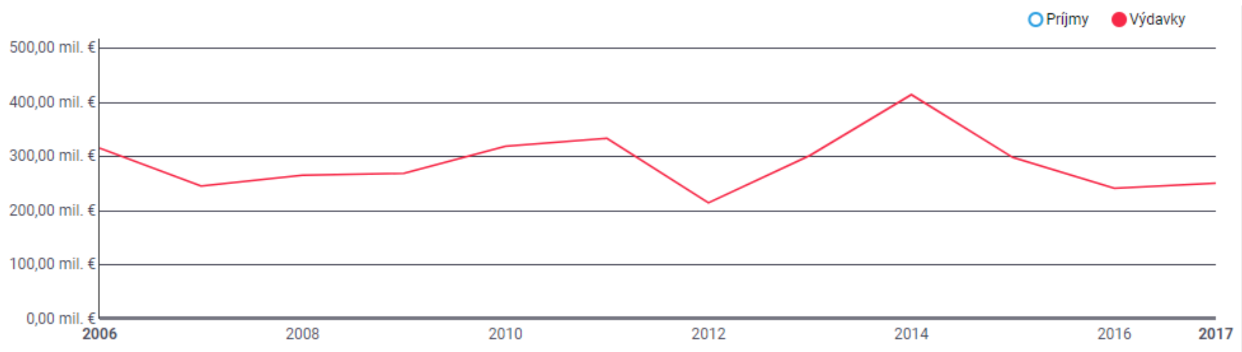
Fig. 28: Slovak energy security budget – upper interval (in mil. €)



Both budget proposals show that the new NPP remains by far the biggest cost item, even if its divided into eight yearly instalments. The highest budget spike takes place when the construction intervals of the SK-PL oil pipeline and the new NPP overlap – year 2023 in the budget proposals. Even though it can be smoothened by EU funds for oil pipelines (which are not included), the presence of the NPP project overshadows all other items in the budget. It should be taken into consideration, that these are only the construction costs of projects – operation and maintenance costs, decommissioning costs of the old NPP Bohunice, financing costs etc. are not included in the budget proposal. It should also be considered, that these are only costs of energy security related investments, whereas the national energy policy has also other goals to fulfil, e.g.: inclusion of renewables, energy efficiency increase, GHG reduction, which require additional expenses from the government. Other energy projects, that are not necessary to build from pure energy security perspective, such as Eastring or additional hydropower projects, are also not included in the proposal.

Within the Slovak government, the Ministry of Economy is responsible for carrying out energy policy and for management of state companies that participate in energy projects. The proposed budget should therefore be compared with the overall budget of the ministry.

Fig. 29: Ministry of Economy of the Slovak Republic – yearly expenses



Source: Ministry of Economy of the Slovak Republic

It is clear from the graph, that the budget of the entire ministry oscillates around the 300 mil. € mark. The pipeline projects could fit within that budget, especially with additional EU funding. However, the new NPP would require a separate financial plan, due to its extraordinary costs.

To sum up, Slovakia faces two challenges related to energy security investment – diversification of oil and gas transport routes and modernisation of nuclear energy production. Both require considerable investment, however the former is much less of an economic challenge than the latter. Diversification of routes requires more effort in the field of economic diplomacy, both in relation to EU and to countries participating on joint projects. Construction of a new NPP, coupled with decommissioning of the old one must be regarded as a project of national importance, since nuclear power is by far the most important source of energy, and the key solution to decarbonization of Slovak economy. The project will face heavy criticism from Germany and Austria, both key trade partners of Slovakia. Successful overcoming of these challenges merely begins at successful acquisition of necessary finances.

5 Conclusion

In terms of the thesis, it heavily relies on the MOSES model and Slovak energy policy, both imperfect due to their own biases and partial interests. Statistical data used in the thesis was mostly consistent, but in some cases not readily available – assuming and simplifying based on available information was in many cases the only way how to progress with the writing of the thesis. Originally, the final part consisted of several different scenarios, related to phasing out energy sources – however the amount of information and the level of abstraction needed would not yield usable results. The results of the model scenario show that Slovakia needs to commit to several key infrastructure projects, without which it will not reach the highest level of energy security for a country if its size. As a small, export oriented, open economy, with no significant natural resources, Slovakia is and will remain vulnerable and dependent. The key issue is to be able to be partially dependent on multiple sources than to be completely dependent on one.

Ultimately, the original motivation behind increasing energy security is to firmly cement Slovakia's inclusion to the European West. In the field of energy security, this is to be done by adhering to EU principles and regulations (on whose development may Slovakia participate), by connecting all layers of energy infrastructure to neighbouring EU member states, and by reducing Russia's share of total energy imports to a level on which it will be forced to behave like just another trade partner, not like a hegemon using energy exports as a tool to further his political agenda. Slovakia isn't a unique case of having Russia as a dominant supplier of energy – the entire CEE region, 27 years after the fall of the Berlin Wall, has to deal with, among others, Gazprom and Rosatom, companies through which Russia abuses their monopolistic position on the market in order to keep a certain level control over countries of the region, especially over those, that have already decided to join the rest of the developed EU in its path to prosperity. Slovakia, along with other EU members of the former Eastern Bloc, are well on their way to sever their last significant tie to Russia, which has its origins from the times of the Stalinist dictatorship, and reduce it to a mere trade partnership. This way, Slovakia may begin a new chapter of relations with Russia, untainted with lingering memories of the past.

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Summary

Twenty-eight years after the Velvet Revolution, Slovakia is still completely dependent on Russia for primary energy supply. Longstanding economic ties to Russian suppliers and lack of alternative infrastructure are the main reasons for this state of affairs. Facing economy decarbonization, emergence of renewable energy sources and pressures for market liberalization, Slovakia needs to make decisions, that will ensure future stable, sufficient and uninterrupted supply of energy.

The goal of this Master's thesis is to analyse the current state of Slovak energy security, suggest improvement measures, estimate their investment cost and project a budget proposal, with implementation period being 2018-2030. Analysis of Slovak energy security is done via IEA Model of short-term energy supply (MOSES), whereas the Energy Policy of the Slovak Republic (2014) serves as a guideline for improvement planning.

According to the model's results, Slovakia needs to invest in several international oil and gas pipelines, and build a new nuclear power plant, in order to reach a higher level of energy security by 2030. The projects are costly and will require financial support of the EU or a bank loan. In addition, profitability of the projects is not ensured for all investments, and they may require further subsidization during their operation. But overall, since Slovakia is a country with no substantial indigenous sources of energy, these investments will ensure that the country will no longer be dependent on a single source of energy, flowing through a single transit country.

Zusammenfassung

Acht-und-zwanzig Jahren nach der samtenen Revolution, die Slowakei ist immer noch von der russischen Primärenergieversorgung abhängig. Langjährige Wirtschaftsbeziehungen zu russischen Lieferanten und Mangel an alternativer Infrastruktur sind die Hauptgründen für diesen Zustand. Angesichts der Wirtschaftsdekarbonisierung, des Aufkommens von erneuerbaren Energiequellen und des Marktliberalisierungsdrucks, die Slowakei muss Entscheidungen treffen, die die künftige sichere, ausreicheinde und ununterbrochene Energieversorgung sichern werden.

Ziel dieser Masterarbeit ist den gegenwärtigen Zustand der slowakischen Energiesicherheit zu analysieren, Verbesserungsmaßnahmen vorzuschlagen, Investitionskosten abzuschätzen und einen Budgetvoschlag zu entwerfen, mit Realisierungsperiode von 2018 bis 2030. Analyse der slowakischen Energiesicherheit wird mittels IEA Modell der kurzfristigen Energieversorgung (MOSES) durchgeführt, wohingegen die Energiepolitik der Slowakischen Republik (2014) dient als Leitfaden für Verbesserungsplanung.

Laut den Ergebnissen des Modells, die Slowakei braucht in mehreren Öl- und Gasrohrleitungen zu investieren, und ein neues Atomkraftwerk zu erbauen, um bis 2030 ein höheres Niveau der Energiesicherheit zu erreichen. Die Projekte sind aufwändig und werden entweder finanzielle Unterstützung der EU oder ein Bankdarlehen benötigen. Außerdem, die Rentabilität von allen Projekten ist nicht gewährleistet, und sie können während ihrem Betrieb weitere Subventionierung erfordern. Summa summarum, da die Slowakei ein Land ohne wesentlichen landeseigenen Energiequellen ist, diese Investitionen werden sicherstellen, dass sie nie mehr von einer einzigen Energiequelle, fließend durch ein einziges Transitland abhängig wird.